ORDER

6000.22A

MAINTENANCE OF ANALOG LINES

December 30, 1996

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Distribution: A-FAF-0 (MAX); X(AF)-3; ZAF-604 Initiated By: AOS-260

FOREWORD

1. PURPOSE.

a. This handbook prescribes technical standards, tolerances, and procedures applicable to the acceptance, maintenance, and inspection of FAA-owned and leased analog lines. It also provides information on methods and techniques that enable maintenance and technical personnel to achieve optimal performance from the equipment and transmission services. This order augments information available in instruction books and other handbooks, and complements the latest edition of Order 6000.15, General Maintenance Handbook for Airway Facilities.

b. This handbook implements Configuration Control Decisions (CCD): N13252, Modification to Form 6000-9, Two-Point Private Line Performance Record--Voice Grade; N10386, Clarification of Leased Landlines Standards and Tolerances; N10274, Change Order 6000.22, Maintenance of Two-Point Private Lines; and N11284, Order 6000.22 (Chg 1-8) Maintenance of Two-Point Private Lines.

2. DISTRIBUTION. This order is distributed to selected offices and services within Washington headquarters, the William J. Hughes Technical Center, and the Mike Monroney Aeronautical Center; to the branch level within the regional Airway Facilities divisions; and to all Airway Facilities field offices.

3. CANCELLATION. This handbook cancels Order 6000.22, Maintenance of Analog Lines, dated August 9, 1976.

4. MAJOR CHANGES. Major changes included in this revised Order 6000.22 are:

a. An updated and revised list of the types of analog lines used within the FAA.

b. A revised list of circuit parameters that includes only those most useful and necessary in determining overall circuit quality.

c. A reduction in periodic circuit maintenance where there is real-time and continuous monitoring.

d. Details on use of Automatic Line Test Equipment (ALTE) and responders as well as acceptance of automated testing printouts.

e. Parameters and tolerances for composite analog lines.

5. MAINTENANCE AND MODIFICATION POLICY.

a. Order 6000.15, this handbook, and the applicable equipment instruction books shall be consulted and used together by the maintenance technician in all duties and activities for the maintenance of analog lines. These three documents shall be used as the official source of maintenance policy and direction authorized by Operational Support. References located in the appropriate paragraphs of this handbook entitled Chapter 3, Standards and Tolerances, Chapter 4, Periodic Maintenance, and Chapter 5, Maintenance Procedures, shall indicate to the user whether this handbook and/or the equipment instruction book shall be consulted for a particular standard, key inspection element or performance parameter, performance check, maintenance task, or maintenance procedure.

b. The latest edition of Order 6032.1, Modifications to Ground Facilities, Systems, and Equipment in the National Airspace System, contains comprehensive policy and direction concerning the development, authorization, implementation, and recording of modifications to facilities, systems, and equipment in commissioned status. It supersedes all instructions published in earlier editions of maintenance handbooks and related directives.

6. FORMS LISTING. Instructions for the use of the following forms are contained in this order.

a. FAA Form 6000-14, Performance Record-Analog Lines, will be used in acceptance and line performance validation. These forms are available as NSN 0052-00-916-2000, unit of issue: PD.

b. Automatic Line Test Equipment (ALTE) and vendor-generated computerized testing system printouts may be filed alone or may be attached to FAA Form 6000-14 in station files.

7. RECOMMENDATIONS FOR IMPROVEMENT. Preaddressed comment sheets are provided at the back of this handbook in accordance with the latest edition of Order 1320.58, Equipment and Facility Directives-Modification and Maintenance Technical Handbooks. Users are encouraged to submit recommendations for improvement.

George W. Terrell
Program Director for Operational Support

TABLE OF CONTENTS

SECTION 3. ANALOG PERFORMANCE AND TEST PARAMETERS

Paragraph *Page*

CHAPTER 3. STANDARDS AND TOLERANCES

CHAPTER 4. PERIODIC MAINTENANCE

SECTION 1. PERFORMANCE CHECKS

SECTION 2. OTHER MAINTENANCE TASKS

CHAPTER 5. MAINTENANCE PROCEDURES

LIST OF TABLES

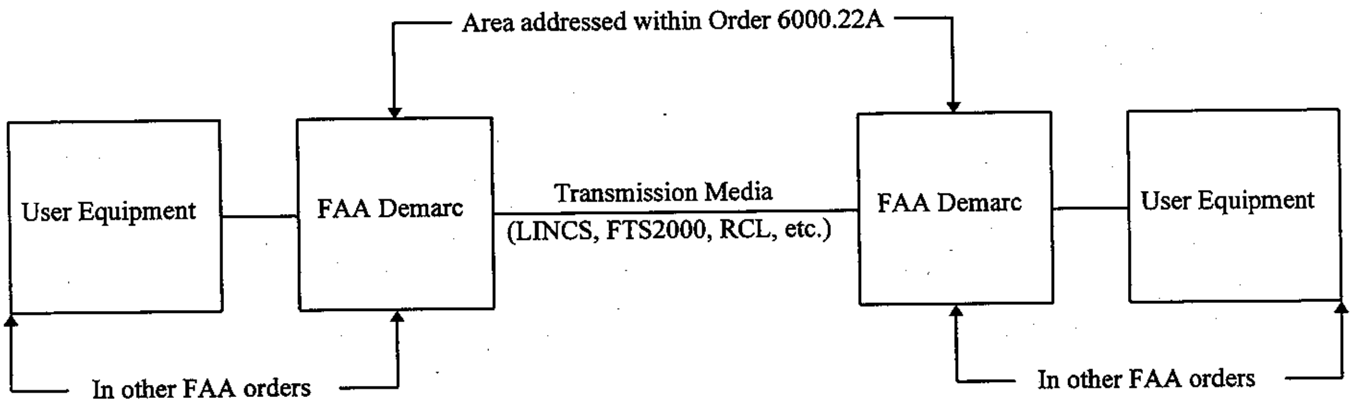
LIST OF ILLUSTRATIONS

CHAPTER 1. GENERAL INFORMATION AND REQUIREMENTS

100. OBJECTIVE. The objective of this handbook is to provide the necessary guidance for the proper maintenance and inspection of FAA analog transmission lines. (The term *analog* refers to an electrical signal that varies in amplitude or frequency depending on changes in the intelligence input, generally an audible voice or tone.) Use information available in instruction books and other handbooks, together with this handbook to provide the total information for maintenance of analog lines. This handbook addresses the maintenance of analog transmission lines between FAA demarcation (demarc) points as shown in figure 1-1. FAA communications systems - both leased and owned - provide a transmission utility for the support of services (e.g., air-to-ground radio communications between controllers and aircraft.) Figure 1-1 below depicts the area of coverage of this handbook which is on the transmission media provided between the demarcation points located within FAA facilities. The maintenance and operation of the customer premise equipment (CPE) or network terminating equipment (NTE) - both located on the customer side of the demarc - are addressed in other FAA handbooks and publications. The term *analog line* refers to the format appearing on the user side of the demarc (regardless of the transmission media used within the network.) In other words, an analog line is in analog format on the user side of the FAA demarc.

101. RESERVED.

FIGURE 1-1. COVERAGE OF ORDER 6000.22A



SECTION 1. ANALOG LINE INFORMATION

102. SERVICE SPECIFICATIONS IN EFFECT.

a. LINCS. The majority of FAA's leased analog operational lines are provided under the Leased Interfacility National Airspace System Communications System (LINCS) contract, currently with MCI Telecommunications Corporation. Although the LINCS contract has provisions for both analog and digital lines, this handbook only addresses analog lines.

(1) Voice Grade Type 6 (VG-6) Lines. Typical applications of VG-6 lines are to provide voice and low bit rate data service (9.6 kilobits per second [kb/s], or slower.)

(2) Voice Grade Type 8 (VG-8) Lines. Typical applications of VG-8 lines are to provide voice grade data support at speeds greater than 9.6 kb/s.

(3) The Defense Information Technology Contracting Office (DITCO) at Scott Air Force Base near Belleville, Illinois, is the FAA's contracting office for leased telecommunications.

(4) MCI will provide multipoint lines when ordered by the FAA.

b. FTS2000. The General Services Administration (GSA) manages the Federal Telecommunication System (FTS2000) program for use by all elements of the United States Federal Government. The GSA has national contracts with AT&T and SPRINT to provide administrative telecommunications for the government. The FAA uses the AT&T contract to provide its administrative communications lines and some selected operational lines.

c. Other Leased Lines. Prior to FTS2000 and the LINCS, the FAA obtained leased lines from numerous vendors that provided almost 20 different types of analog lines.

(1) Line Types. This handbook will document other types of lines still being used by the FAA (e.g., service type 1, and service type 5; C-conditioned types 1, 2, 3, and 4; and lastly D-conditioned types 1 and 6.) This category of *other leased lines* is rapidly shrinking in quantity, as well as variety, and it is expected that virtually all of the FAA analog leased lines will soon be provided either under the LINCS contract or by FTS2000.

(2) Line Conditioning. Within the FAA, there are older existing lines with C- or D-type conditioning but no new conditioned lines will be leased. One method used to improve the passband characteristics of a leased telephone line and thereby increase the information capacity of a telephone system is to provide special conditioning on the line. To obtain high-speed data on these few, older, non-LINCS voice-grade lines, attenuation distortion, envelope-delay distortion, signal-to-noise ratio, and harmonic distortion had to be controlled. The first two (attenuation distortion and envelope delay distortion) were controlled through C-conditioning and the latter two (signal-to-noise ratio and harmonic distortion) by D-conditioning.

d. FAA Owned Transmission Systems.

(1) RCL/LDRCL. The radio communications link (RCL) microwave network is an FAA owned voice and data transmission system procured to provide FAA with cost-effective and reliable service for the NAS. The RCL provides an interconnected national RCL backbone network among ARTCC's. In addition to the backbone RCL network, the low density RCL (LDRCL) system provides local communications routes that tie remote facilities (such as terminal radar) to the hub air traffic control facilities or to the RCL backbone.

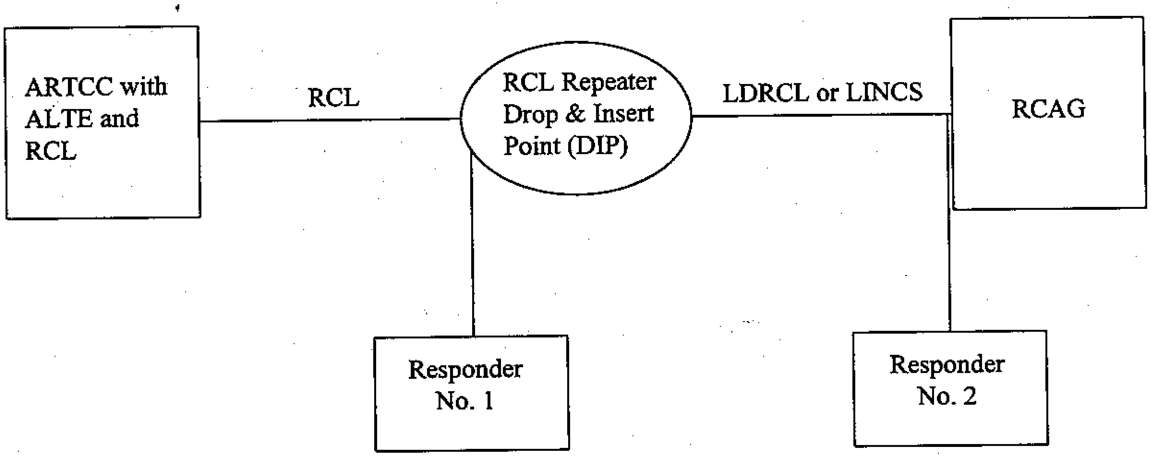
(2) Microwave and Cable Systems. There are some regionally procured transmission systems that use older FAA-owned microwave or cable (metallic or fiber) between facilities. Standards, covering the lines these facilities provide, are not included in this order but should be provided by regional supplements to this order.

e. Composite Lines. Composite lines are end-to-end analog lines made up of two or more line segments provided by different suppliers or made up of two individual lines connected together that appear on an analog demarc and are cross connected at voice frequency (vf) level. FAA composite lines may include segments provided by some feasible combination of several types of FAA-owned or leased lines. There are numerous examples of types of composite lines but the large majority are expected to be combinations of LINCS and RCL/LDRCL segments. As an example, assume a voice frequency (vf) line on one RCL link is tied to a line on another RCL link at an ARTCC to create a vf line that goes from one facility through several RCL links to a distant facility. If the cross-connect at the ARTCC's is done at vf level, the line is considered composite. If, however, the cross-connect is done at the T1 level or at the baseband level (as a group or subgroup), this is not a composite line and should meet all specifications and parameters for an RCL vf line. A diagram of a type of composite line is shown in figure 1-2 below. (The responder numbering scheme reflected in this figure may differ from the numbering schemes used in other regions.)

f. Multipoint Lines. A line that has more than two termination points is called a multipoint line. Typical FAA applications that use multipoint lines are the voice interphone circuits used for coordination and hand-off between controllers. There are data applications that also use multipoint lines. See chapter 7 for a more complete discussion on multipoint lines.

103.-106. RESERVED.

FIGURE 1-2. COMPOSITE LINE DIAGRAM



SECTION 2. MAINTENANCE ACTIVITIES

107. SAFETY. Personnel should observe all safety precautions when working on equipment. For guidance refer to the latest edition of Order 6000.15.

108. CERTIFICATION. There are no certification requirements for leased or FAA-owned lines. Such lines may be included as part of a certified system and would then need to provide the required service for the system being certified. These services using the leased or FAA-owned lines are included in appropriate FAA equipment orders.

109. COORDINATION OF MAINTENANCE ACTIVITIES.

a. Maintenance activities shall be coordinated with operations personnel to preclude interruptions to Air Traffic Service. Sufficient advance notice shall be given for maintenance activities so that, if required, appropriate Notices to Airmen (NOTAM's) can be issued. The information necessary for the preparation of such NOTAM's shall be furnished promptly. Operations personnel should recognize the need for releasing equipment for scheduled maintenance work and should offer their cooperation to assure continuous and reliable operation. Refer to the latest edition of Order 7210.3, Facility Operation and Administration, for information on air traffic and maintenance coordination requirements to effect scheduled maintenance activities.

b. FAA technical personnel should notify the MCI FAA Network Management Center (FAANMC) network operations group or help desk before performing compression testing, removing carrier from a VG-8 line, or initiating any planned effort on a LINCS line that will cause alarms in the LINCS monitoring system. Examples of such activities that might cause LINCS alarms are power maintenance, modem maintenance on VG-8 lines, switching a VG-8 line to the backup facility, or any activity that will cause the LINCS Newbridge monitoring equipment to sense an out-of-tolerance condition. See table 1-1 for the MCI help desk telephone number.

110. REPORTING IRREGULARITIES, INTERRUPTIONS, AND OUTAGES. After diagnostic testing to assure that FAA equipment is not at fault, the System Management Office (SMO) manager or representative at the control end of the line shall be responsible for reporting the service difficulty.

a. LINCS. The SMO manager or representative shall contact the MCI LINCS help desk.

(1) The MCI LINCS help desk provides a single point-of-contact for real-time trouble management of the entire LINCS network. It is manned 24 hours a day, 7 days a week. This group fields all user calls and provides first-level trouble reporting and resolution assistance. The help desk initiates and tracks requests for corrective action and ensures that escalation notifications are conducted within contractually set time parameters. The help desk also has the capability to remotely conduct parameter checks on lines within MCI and with other vendors that provide LINCS lines. The technical assistance section within the help desk coordinates restoration activities with the assigned maintenance service organization. This technical assistance section directs the service efforts that extend between different maintenance organizations. They also verify that restored services meet network specifications before returning them to active status.

(2) The MCI LINCS program management office (PMO) network operations element within the LINCS PMO network management function provides second-level support by receiving troubles or questions that the help desk is unable to answer.

(3) If there are questions that cannot be resolved by the network operations element, the help desk obtains third-level trouble assistance from the network engineering function supported by the network equipment provider.

(4) The LINCS national service management element, within the MCI LINCS PMO, has direct responsibility and accountability for LINCS performance. Each FAA region has a regional service manager (RSM) that reports to the national service manager (NSM). The NSM is responsible for coordinating regional activities between the LINCS PMO and the RSM's. . The NSM reports to the LINCS PMO director.

1 The RSM's play a critical role in managing the deliverables and performance of services to the FAA. RSM's provide performance analysis of the network, prioritizing FAA issues within MCI to direct MCI resources onto high priority service issues based on their knowledge of FAA applications, operations, and organizations. Each RSM reviews chronic troubles and makes escalations as required. Each RSM collects and analyzes data relative to their region and produces monthly status reports for review with MCI operations and the FAA.

2 The RSM's are responsible for screening all maintenance requests, for both FAA and MCI requests. The RSM's determine the impact to the FAA and coordinate with the FAA for notifications and approvals. In addition, the RSM's assist the FAA Network Management Center in coordinating maintenance releases for LINCS circuits for both routine and emergency maintenance. RSM's provide a primary ongoing liaison function between the FAA regions and MCI. The RSM's serve as primary contact for any technical or administrative issues within their respective regions.

b. FTS2000. The General Services Administration (GSA) is the manager of service providers for the FTS2000. GSA oversees management functions, ensures contract compliance, and supports the FAA if problems should arise with AT&T, the company supporting the FAA as the FTS2000 service A provider. The FTS2000 contract requires that both GSA and AT&T operate customer service organizations.

(1) The AT&T customer service office (CSO) is the first point of contact for FTS2000 network troubles and user complaints. This 24 hours per day, 7 days per week office is the first resource an FAA manager or his representative will contact when in need of FTS2000 customer support.

(2) Call the GSA FTS customer satisfaction center to escalate any problem already reported within FTS2000. This office is open from 7 am till 9 p. m. eastern time, Monday through Friday.

c. Other Leased Lines. For now, and in the very near future, the FAA will continue to use a decreasing number of leased lines provided by local exchange carriers (LEC's). Reporting to, and coordination with these LEC's will be in accordance with existing guidance and procedures.

d. RCL/LDRCL.

(1) For analog lines provided by the RCL or LDRCL networks, the FAA is the serving company and is responsible for service restoration. The microwave links that comprise these networks utilize redundant rf channels designated A and B, with one of these channels being used for service and the other for hot backup. In normal operation, automatic switching is in place to sense the loss of a channel and switch service to the backup channel. However, a manual override is available to defeat the automatic switching. Should a service failure occur, ARTCC personnel controlling the link will assess the cause of the failure and exercise commands through the ACORN Network Management System to restore the service (ACORN is the name, not an acronym, for the RCL network control system.) ARTCC personnel will then notify the maintenance technician responsible for the site that failed.

(2) Prior to any maintenance or repair action being taken on an RCL link that will result in loss of a channel, ARTCC personnel will ensure that the service is protected by verifying that the standby channel is operating normally prior to switching service to that channel. Note that the switching action should be taken for both high density terminals on either end of the link and for all drop and insert point (DIP) sites along the link, and that the switches should be left in the manual mode (i.e. override automatic switching). Upon completion of the maintenance or repair action, ARTCC personnel should ensure that the repaired channel is operating with no alarms, then set the switching capability to the automatic mode.

e. FAA Owned Microwave or Cable Not Listed Above. Reporting outages and coordination of maintenance will be in accordance with regional or SMO guidance.

f. Table 1-1 lists the telephone numbers to contact for reporting trouble on FAA analog lines.

TABLE 1-1. CONTACTS FOR REPORTING TROUBLE

SERVICE PROVIDER	CONTACT
LINCS	MCI LINCS help desk at 1-800-68 LINCS (1-800-685-4627). In an emergency when the help desk is unreachable call 1-800-293-5844, (919) 677-5696, or the alternate LINCS help desk on (703) 414-9615.
FTS2000	
1. Reporting to AT&T	1-800-332-4387 or (703) 442-4387
2. Reporting to GSA	(703) 760-7500
Other leased circuits	In accordance with existing guidance and procedures.
RCL/LDRCL	In accordance with existing guidance and procedures.

111. TROUBLESHOOTING.

a. Leased Lines. For leased lines, troubleshooting and repair are the responsibility of the serving company. FAA personnel should ensure that FAA equipment or interconnecting FAA lines are not at fault before reporting trouble to the serving company. FAA personnel should be prepared to support the serving company's legitimate requests for assistance in troubleshooting and fault isolation. Refer to the latest edition of Order 6030.41, Notification Plan for Unscheduled Facility and Service Interruptions and Other Significant Events.

b. FAA-Owned Lines. Troubleshooting and repair of FAA-owned lines will be conducted as specified in this and other applicable manuals.

112. NAS CHANGE PROPOSALS. If an analog line will not meet the standards and tolerances specified in this handbook but must still be used, a local NAS change proposal (NCP) will be submitted. This NCP should specify the usage and performance of the line on which the NCP is submitted and provide a description of and schedule for any efforts planned as a permanent resolution. Procedures for submitting an NCP are specified in the latest edition of Order 1800.8, National Airspace System Configuration Management. Instructions are contained in the front of NAS-MD-001, National Airspace System Master Configuration Index.

113. PRECAUTIONS WHEN USING TEST TONES. Test tones used in line maintenance are potentially interfering and disorienting and may have negative effects on human and equipment performance. If test tones have not been properly blocked out from the equipment sides of a line under test, they may cause major irritation and disorientation of personnel still on the line. Follow specific procedures detailed in chapter 5 for when and where to apply test tones. Also, keeping tones at or below maximum levels will help in avoiding annoyance to personnel or causing interference in adjacent carrier channels.

114.-199. RESERVED.

CHAPTER 2. TECHNICAL CHARACTERISTICS

200. PURPOSE. Analog communications lines are used by the FAA to support both voice and data applications. This chapter provides technical background on telecommunications lines as well as the various techniques and measures used in installation, performance testing, troubleshooting, fault isolation, and restoration of analog lines.

201. RESERVED.

SECTION 1. TECHNICAL DESCRIPTION

202. SYSTEM OVERVIEW.

a. Human speech generates analog energy that moves from the mouth of the speaker to the ear of the listener. Telephones, radios, and other speech transmission devices are designed to accept the input of the analog wave generated by the sounds of speech, convert them to electrical waves that have similar amplitude, and then modulate a receiving device at the distant end that reproduces the same analog wave generated by the person who spoke. Equipment can also be controlled by using a sequence of audio control tones or pulses. The analog signal produced by either the speaker or the control equipment is then transmitted to the remote listener or equipment by a carrier system, which can use either analog or digital technology.

(1) Analog transmission carrier systems are provided by the FAA's RCL system and by one version of the LDRCL systems. For limited distance applications, analog transmissions will be routed over cable and wire systems. A carrier system is used to transmit a number of voice or signaling lines over a single transmission facility. The total number of voice and signal lines that may be handled over one carrier facility depends on the design of the system. For example, the RCL carrier system uses a frequency division multiplexer (FDM) to provide up to 600 voice frequency lines. Both the RCL and LDRCL have the capability of being implemented using digital technology with the RCL providing analog and data above voice (DAV) while the LDRCL provides analog or digital (DS1).

(2) Analog signals can be digitized and then transmitted over the increasingly more available digital transmission systems. The analog waveform is first digitized by an analog-to-digital (A/D) converter using a technique called pulse code modulation (PCM). The resulting digital bits of the converted waveform are encoded and sent over the digital transmission system. At the receiving end, the digital signal is converted back to the analog waveform by a digital-to-analog (d/a) converter. The steps required to convert and transmit an analog signal over a digital transmission system are discussed below.

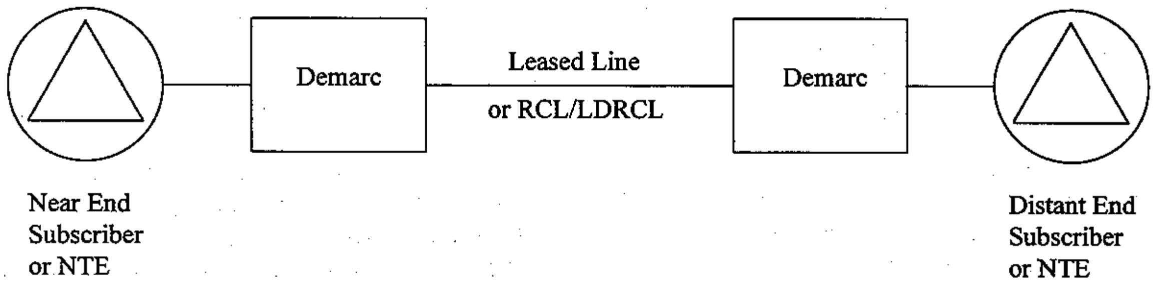
(a) A telephone or modem produces a voice band analog signal that is band limited to 4000 Hertz (Hz). The resulting voice band amplitude is sampled at a rate equal to twice the highest information rate. This rate of sampling is called the Nyquist rate. It has been demonstrated that the minimum sampling frequency required to extract all the information contained in the original signal is two times the original signal bandwidth. Thus, for this example, with a 4000-Hz bandwidth for the voice signal, the Nyquist rate is 4000 x 2 = 8000. This signal is a series of pulses that follows the amplitude of the analog waveform and is called a pulse amplitude modulated (PAM) representation of the original analog signal.

(b) Pulse code modulation (PCM) is an extension of PAM. PCM is the most common method of digitizing analog signals. This PCM sampling process converts a vf analog line into a 64 kb/s standard rate known as digital signal level zero (DS-0). PCM is a two step technique. First the incoming analog signal is sampled 8000 times per second. These samples are then converted to pulses using the PAM process. In the second step of PCM conversion, the amplitude of each pulse of the PAM signal is converted to an 8-bit digital pulse stream by an analog-to-digital (a/d) converter. The resulting output is a digital representation of the pulse stream and the sampled analog waveform. The signal-to-noise ratio is maximized by nonlinearly converting the level of the PAM signal to digital values. Low amplitude PAM signals are encoded to have a higher degree of resolution to compensate for low level noise. Likewise, higher amplitude PAM signals require less digital resolution because their noise levels are much less significant. The output of the a/d converter is one of 256 possible digital values represented in eight bits ($2^8 = 256$). The eight bit PCM signal is then converted to a serial bit stream for eventual digital transmission. The resulting rate of the bit stream is: 8000 Hz sampling rate of the PAM signal x 8 bits per sample = 64,000 bits per second, or 64 kb/s.

b. Transmission Impairments. Three variables affect the adequacy of voice communications: level or volume, noise, and bandwidth. For data communications, attenuation distortion and envelope delay are also important.

(1) Level or Volume. Consider the simple telecommunications line illustrated in figure 2-1. The telephone or other network termination equipment (NTE) converts the changes in air pressure of sound waves from a speaker's voice to a varying electrical current that is an analog of the acoustic signal. The electrical characteristics of the line between the sending and receiving instruments modify the electrical signal in such a way as to reduce its volume (or increase its loss), change the bandwidth of the signal, and may generate extraneous signals such as noise, crosstalk, and distortion. Loss is overcome by amplification in telecommunications lines. But amplifiers or repeaters cause undesired side effects as well as the desired effect of offsetting loss. In addition to their cost, repeaters also add distortion in the form of limiting bandwidth and adding noise.

FIGURE 2-1. TYPICAL TELECOMMUNICATIONS LINE



(2) Noise. Noise is defined as any unwanted energy on a line. There are definite trade-offs among the various noise impairments and the quality of the signal as perceived by the listener. The most important measurement of noise is the signal-to-noise ratio expressed in dB. Data signals exhibit an entirely different tolerance to noise than do humans. A data signal might be satisfactory in the presence of uniform steady hissing or white noise that would be bothersome to humans. On the other hand, impulse noise (clicks or pops) will destroy a data signal on a line that might be satisfactory for speech communications. Phase and gain hits are abrupt changes in the phase or amplitude of a received sinusoidal wave. The three primary sources of line noise are external sources (power lines, lightning, nearby electrical apparatus, and crosstalk from adjacent telecommunications lines); thermal noise developed within the telecommunications equipment; and distortion generated by nonlinearities in line elements, primarily amplifiers. The small imperfections in an amplifier's transfer characteristics distort the amplified signal so that extra signal components appear in the output signal; this is aggravated by operating the amplifier beyond its design capability.

(3) Bandwidth. Bandwidth is the line attribute that, along with frequency response, controls the naturalness of transmitted speech. As with level, this is a subjective evaluation. The human ear can detect tones in the range of 20 to 16,000 Hz, but because the voice has little energy component below 300 Hz or above 3,500 Hz, a telephone line that transmits a band of frequencies in this range is quite adequate for voice communications. Telephone receivers have been designed to be most sensitive to the frequencies between 500 and 2,500 Hz because research has shown that most of the frequency components of ordinary speech fall within this range. Because of the difficulty of constructing filters and amplifiers with uniform transmission at all frequencies within the pass band, the high- and low-frequency ends of the transmitted spectrum suffer more loss or attenuation than frequencies in the center of the band.

(4) Attenuation Distortion. Telecommunications lines rarely have a perfectly flat response across the voice frequency band. Lines can be brought into close tolerance by the addition of equalizers where the cost of the treatment is justified by the demands of the service.

(5) Envelope Delay Distortion. The design of amplifiers and multiplexers requires components that introduce varying amounts of delay to different frequencies within the voice frequency (vf) passband. For example, a vf signal near the center frequency of a vf passband filter will transit through that filter much faster than a vf signal near the band edge of the filter. This characteristic is known as envelope delay. Data signals are composed of complex vf tones. Envelope delay results in these tones arriving at the receiver at different times, resulting in a signal at the receiver that is not identical to the original signal. Delay equalizers in the line or terminal equipment are used to compensate for envelope delay.

(6) Phase Jitter. Phase jitter is defined as the unwanted change in phase or frequency of a transmitted signal due to modulation by another signal during transmission. If a simple sinusoid frequency is frequency or phase modulated during transmission, the received signal will have sidebands. The amplitude of these sidebands compared to the received signal is a measure of the phase jitter imparted to it during transmission. Phase jitter is measured in degrees of variation peak to peak for each hertz of transmitted signal. Phase jitter shows up as unwanted variations in zero crossings of a received signal. Since it is the zero crossings that most data modems use to distinguish marks and space, the higher the data rate, the more jitter can affect the error rate of the received bit stream. Modulation components defined as jitter usually occur close to the carrier from about 0 to ± 300 Hz maximum.

203. ANALOG TRANSMISSION SERVICES.

a. Decibel.

(1) The decibel (dB) is a logarithmic unit that describes a ratio. Voice frequency lines are designed around the human ear, which has a logarithmic response to changes in power. Therefore, in telephony the decibel, a logarithmic rather than a linear measurement, is used as a measure of relative power between lines or transmission level points. A change of 1 dB is barely perceptible under ideal conditions. Increases or reductions of 3 dB result in doubling or halving the power of a line and are readily detectable to the average listener's ear. This is a good figure to remember: doubling the power means a 3-dB gain; halving the power means a 3-dB loss.

(2) Consider a power ratio. The number of decibels (dB) = 10 $\log_{10}$ (the ratio between the input and output power levels). As a formula this is written:

$$\text{number of decibels} = 10 \log_{10} \frac{P_1}{P_2}$$

where P_1 is the measured power level and P_2 is the reference power level.

(3) When a line has 10 dB of attenuation, it means the output power is only one-tenth of the input power. If the input power is 1 milliwatt (mW) and the output power is 0.1 mW, the line loss is 10:1. The power ratio is 10 to 1 and the attenuation is 10 dB. It is useful to make simple calculations concerning decibels without needing pencil and paper. Consider the relationship of power ratios and decibels shown in table 2-1.

TABLE 2-1. RELATIONSHIP OF POWER RATIOS AND DECIBELS

Power Ratio		dB	Power Ratio		dB
10^1	(10)	+10	10^{-1}	(1/10)	-10
10^2	(100)	+20	10^{-2}	(1/100)	-20
10^3	(1,000)	+30	10^{-3}	(1/1,000)	-30
10^4	(10,000)	+40	10^{-4}	(1/10,000)	-40
10^5	(100,000)	+50	10^{-5}	(1/100,000)	-50
10^6	(1,000,000)	+60	10^{-6}	(1/1,000,000)	-60

b. Basic Derived Decibel Units.

(1) dBm. Where dB specifies a relative power ratio, dBm specifies an absolute power level. By definition dBm is a power level referenced to 1 milliwatt (mW) in which 0 dBm = 1 mW. The formula is written:

$$\text{Power (dBm)} = 10 \log \frac{\text{power (mW)}}{1 \text{ mW}}$$

For example, an amplifier with an output of 20 W has an output in dBm of:

$$\text{Power in dBm} = 10 \log \frac{20 \text{ W}}{1 \text{ mW}}$$

$$= 10 \log \frac{20 \times 10^3 \text{ mW}}{1 \text{ mW}}$$

$$= +43 \text{ dBm}$$

The plus sign in this answer indicates that the level is above the reference, 0 dBm or 1 mW.

(2) dBm0. The notation dBm0 is an absolute power level and is used to indicate the power level reading relative to 0 TLP, or what it would read if corrected to account for gains or losses. Thus a dBm reading of -6 dBm at a +7 TLP (transmission level point) would be corrected to a -13 dBm0. (-6 dBm -[+7 TLP] = -13 dBm0)

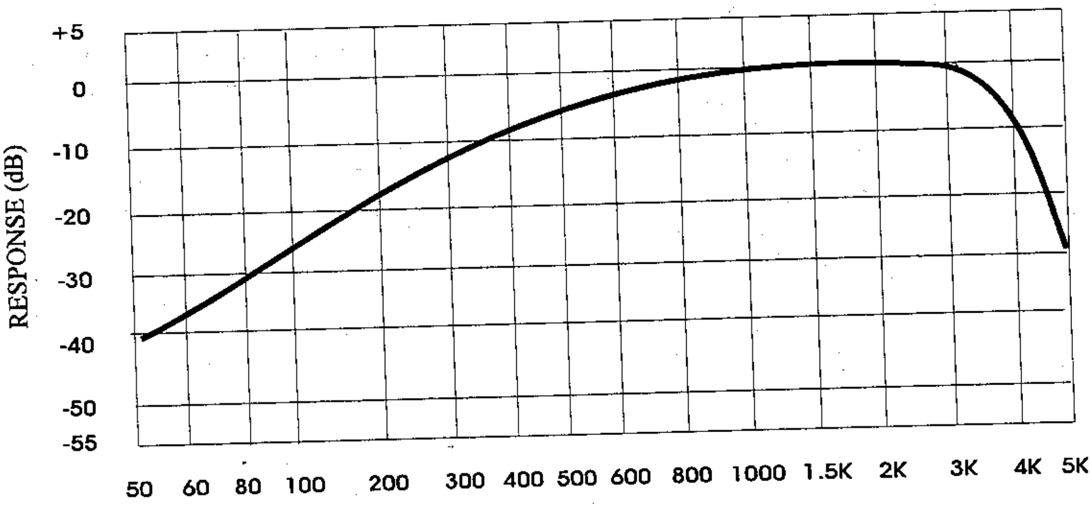
(3) dBRN. Noise is measured with respect to a reference noise level of -90 dBm or 1 picowatt (pW) or one trillionth (10^{-12}) watt. This level, defined as 0 dBRN, is at the threshold of human audibility. Noise level is expressed in decibels above this reference noise as dBRN. In general, for broadband noise, dBm = dBRN - 90 or dBRN = dBm + 90.

(4) dBRNC.

(a) Not only the level but also the frequency of noise determines its interfering effects on human perception. If noise is evenly distributed across the voice frequency band (called white noise) the noise in the 500- to 2500-Hz range will be more annoying to the listener than low and high frequency noise because both the ear and the telephone equipment are more sensitive to these middle frequencies. To compensate for this, noise is measured through a C-message weighting filter. This filter, shown in figure 2-2, passes noise in roughly the same proportion as the sensitivity of the human ear.

(b) The notation dBRNC is used when the C-message weighting network is employed (see paragraph 207c(2) on C-message weighting). A notation of 30 dBRNC indicates that the noise level has been C-message weighted and is 30 dB above the reference noise level. White noise over a 300- to 3000-Hz bandwidth, when C-weighted, results in about a 2 dB reduction. Thus, a white noise signal at 0 dBm produces a -2 dBm, or 88 dBRN, C-weighted signal. If the white noise power is -60 dBm, the C-message-weighted noise is -60 + (90 - 2) = 28 dBRNC.

FIGURE 2-2. C-MESSAGE WEIGHTING RESPONSE CURVE



(5) **dBRNC0.** When noise is measured at a zero level TLP, or mathematically adjusted to a zero TLP, it is expressed as dBRNC0.

c. Zero Transmission Level Point (0 TLP).

(1) The signal power level of analog lines must be limited so that it resembles the average telephone voice power that is being carried on a line within the telecommunications network. This control is necessary to avoid signal distortion from carrier overloading, which in turn may cause noise and crosstalk. When measuring various transmission parameters, it is sometimes necessary to describe the power present at a particular point in a line and compare this power to the power present at other points in the line. The power present at a particular point in a line depends on the power at the source, and the loss or gain between the source and that point. Since this information is not always available, it is convenient to describe the power present in the line by comparing it to some standard reference point. The reference point for measuring power is called the zero transmission level point (0 TLP).

(2) Using the zero TLP concept, the power present at a point in a line is described by stating what this power would be if it were measured at the zero TLP. The unit used to describe the power referred back to the zero TLP is dBm0. For example, the value -13 dBm0 signifies that -13 dBm was measured at the zero TLP, or that it would measure -13 dBm if the power measured in a line were corrected to account for the gains or losses between the zero TLP and the point of measurement.

(3) 0,0 TLP indicates that there are two reference points, between which there will be no loss or gain in signal power (unity gain/zero loss circuit). One TLP reference point would be at each of the two terminating FAA/TELCO demarcs on a line. The same levels would be measured at each demarc. This is done to standardize levels and facilitate faster and easier line restorals and, in the case of composite lines, to enable interconnection with no requirements for adjustment by active or passive elements. The FAA transition to 0,0 TLP permits rerouting with no realignment or equipment changes.

(4) Table 2-2 is an example of a line with actual measurements of signal and noise values at several points in the line. It shows a line in which the signal flows from left to right and the level of the signal (or test tone) is measured in dBm at each point in the line. The signal experiences no loss over the leased line. Noise is

also measured (in dBRNC) at each point in the line. In this example, there is a 2-dB increase in noise along the leased line.

d. Power Level on Lines and Test Tones.

(1) The telecommunications industry has established standards to prevent network degradation created by customer premise equipment (CPE). To comply with FAA and industry standards and provide customers with the greatest dynamic range, the maximum sustained level on any FAA-leased analog service cannot exceed -13 dBm averaged over a 3-second period. The interface signal levels must be controlled to prevent transmission facility overload. Test parameters should specify that test tones used in line performance should not exceed a level which will produce a -13 dBm0 level averaged over 3 seconds during actual in-service conditions.

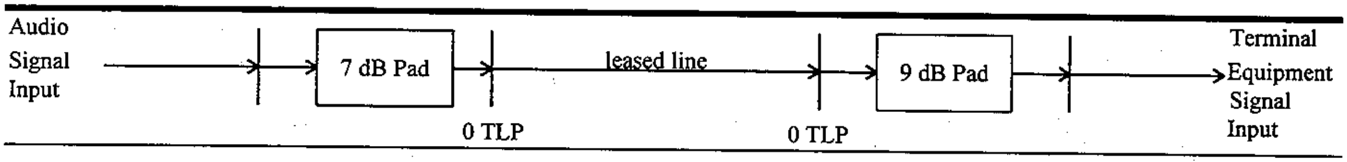
(2) In order for lines to operate at their optimal system performance, and for recorded test data to be valid when compared to actual in-service conditions, it is important that the average transmitted level be as close as practical to -13 dBm at the 0 TLP. A transmitted level less than -13 dBm might cause these undesirable results:

(a) Signal-to-noise ratio decreased by the same amount as the transmitted carrier signal is below -13 dBm.

(b) Impulse noise margin effectively reduced by the same amount as the carrier level is below -13 dBm. Quantizing is the means by which a digital facility samples a signal and assigns a digital code to represent the amplitude (power) of that signal. Digital quantizing within the private network is designed for optimum operation at -13 dBm. A lower signal power level may result in a less than perfect reproduction of the quadrature amplitude modulation (QAM) phase changes in high-speed data modems.

204.-219. RESERVED.

TABLE 2-2. TLP EXAMPLE



TLP	+7	0		0	-9	TLP
dBm	-6	-13		-13	-22	dBm
dBm0	-13	-13		-13	-13	dBm0
dBRNC	20	13	(2-dB noise increase)	15	6	dBRNC
dBRNC0	13	13	(2-dB noise increase)	15	15	dBRNC0

SECTION 2. DESCRIPTION OF SERVICES.

220. PERSPECTIVE. This handbook addresses the maintenance of analog lines between FAA demarcs and does NOT address maintenance of lines within the FAA facility that carry the service to the terminating equipment. In general, the interface between FAAequipment and analog lines will be covered in specific equipment handbooks.

221.-229. RESERVED.

SECTION 3. ANALOG PERFORMANCE AND TEST PARAMETERS

230. PARAMETERS USED IN ANALOG MAINTENANCE AND TESTING. In general, an analog line either is operating normally, is operating with degraded transmission quality, or is completely out-of-service. Maintenance of analog lines involves the identification and monitoring of specific key performance parameters. Lines are monitored to identify statistical degradation over time and to help avoid and detect line outages. Analog lines are also monitored so that contractual obligations can be identified to the communications provider if the line does not comply with system performance specifications. The following discussion of performance and test parameters pertains to both operational line monitoring (in-service monitoring) or when an analog line is taken off-line for maintenance (out-of-service monitoring and testing).

a. 1004 Hz Net Loss. This parameter is a measure of the overall loss or gain of a signal from one end of the line to the other. Measurement of net loss has traditionally been made by transmitting a 1000-Hz test tone and measuring the level of the received tone. The frequency 1000 Hz was chosen since it is roughly in the geometric center of the nominal vf line passband of 300 to 3,400 Hz. (The lower limit is approximately 1/3 of 1000 Hz, and the upper limit is approximately 3 times 1000 Hz.) With the advent of pulse code modulation used when a voice frequency line is sent digitally, the frequency used for net loss was changed to 1004 Hz. Since the pulse code modulation scheme digitizes the signal by sampling at a rate of 8000 Hz, if the test tone frequency was exactly 1000 Hz, the same analog value would be sampled at the same eight points on the 1000 Hz sine wave. Use of such a test tone would not exercise the full range of the a/d and d/a converters used to transmit the analog signal in a digital format. The offset of 4 Hz ensures that the a/d and d/a converters are properly translating the test tone level.

(1) Net loss should be maintained at proper levels to ensure optimum signal performance. If net loss is too high (signal levels too low), signal performance can be degraded by the presence of noise on the line, resulting in a lower signal-to-noise ratio than desired. If net loss is too low (signal levels too high), signal performance can be degraded primarily by distortion. Excessive signal levels can overload lines, and can cause crosstalk or interference with other lines.

(2) For lines implemented with analog equipment, improper net loss is usually the result of improper adjustment of an active component (e.g., amplifier), improper loss through passive components resulting from failed components, or improper connections. For lines implemented with digital format, improper net loss may result from improper setting of transmit and/or receive levels on the channel bank line card, or due to failed components on the channel bank line card.

b. Attenuation Distortion. This is a measure of the change in net loss as the frequency of a signal on the line varies across the voice frequency (vf) bandwidth. It can be measured using a 3-tone slope, which compares the receive levels of tones transmitted at 404 and 2804 Hz relative to the net loss at 1004 Hz, or by sending a series of test tones at 100-Hz intervals throughout the passband of the line and noting the receive level of each frequency.

(1) Minimizing attenuation distortion ensures accurate reproduction of a vf signal composed of energy at numerous frequencies. Minimizing attenuation distortion is particularly crucial for lines carrying high-speed data traffic. High-speed modems generally transmit a carrier signal, which is modulated in some fashion, that results in the signal energy occupying a relatively wide bandwidth. If all frequencies within this bandwidth are not attenuated equally, the modulation of the carrier at the far end will be altered due to the shifting levels of the various frequencies that make up the modulated carrier.

(2) For lines transmitted via analog equipment, improper attenuation distortion is most often the result of failure in filters that set the line passband. Generally, there are no field adjustments available to correct or improve filter passband characteristics. As a result, excessive attenuation distortion is normally corrected by replacing the module or assembly containing the filter that has failed. For lines transmitted in digital format, improper attenuation distortion is most often the result of failed filter components on the channel bank line card.

(3) The attenuation of a transmission line is not flat with frequency, but tends to vary as the square root of the frequency. Attenuation distortion is caused by high frequency components in a signal experiencing greater attenuation than lower frequencies as the signal travels down a transmission line.

c. **Signal-to-C-Notched Noise Ratio.** When noise measurement units were first defined, it was decided that it would be convenient to measure the relative interfering effect of noise on the listener as a positive number. A level of a 1000-Hz tone at -90 dBm or 10^{-12} W (1 pW) was chosen by the U. S. Bell System as a reference because a tone whose level is less than -90 dBm is not ordinarily audible. Such a negative threshold meant that all noise measurements used in telephony would be greater than this number (i.e., positive). The noise measurement unit is the dBRN. (0 dBRN = -90 dBm at 1000 Hz, *RN* standing for reference noise.)

(1) The telephone set in early (1940's) use in North America was the Western Electric 144 handset. A more sensitive handset (500 type) that came into use later gave rise to the C-message line weighting curve and its companion noise measuring unit, the dBRNC. The reference level of -90 dBm was retained.

(2) C-Message Filter. The C-message filter is used to measure idle channel noise present on a line in the absence of a signal. It provides a -5 dB passband between 600 Hz and 3200 Hz. It also sharply attenuates low frequency components, such as 60 Hz and its harmonics (usually related to power lines or power generating equipment), and high frequency components above 3200 Hz. (See figure 2-2.)

(3) C-Notch Filter. Elements in a network transmission system that are active only when the line is active can generate noise. This noise is tested in the presence of a 1004 Hz test tone. To measure the resultant noise, a notch filter is used to remove the test tone by taking the C-message filter and adding a 50 dB stop band (notch) between 995 Hz and 1025 Hz. An ideal C-notch filter response is shown in figure 2-3.

(4) Three-kHz Flat Filter. The 3-kHz flat filter allows measurement of low frequency noise like power induction. See figure 2-4 for the shape of the response for this filter.

FIGURE 2-3. C-NOTCH FILTER RESPONSE CURVE

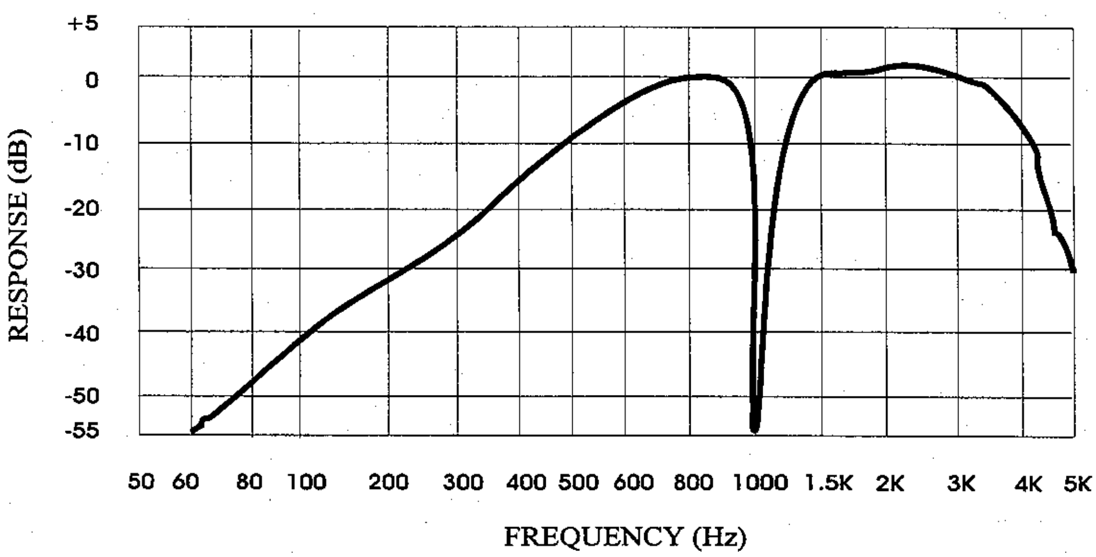
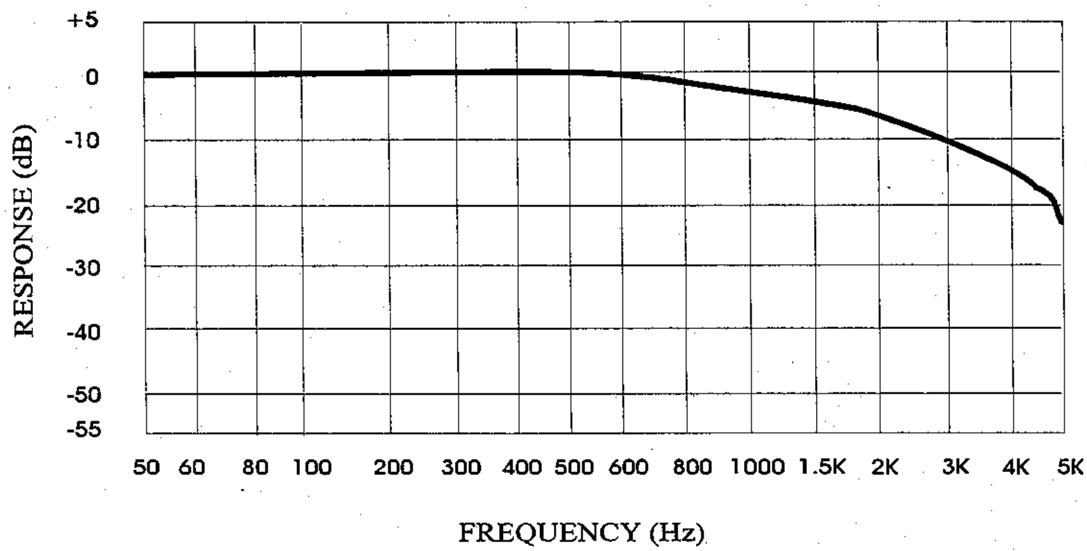


FIGURE 2-4. 3-KHZ FLAT FILTER RESPONSE CURVE



(5) The signal-to-C-notched noise ratio parameter expresses in decibels the amount by which a signal level exceeds its corresponding noise. To measure this parameter, a 1004-Hz test tone at normal tone level (-13 dBm0) is transmitted on the line. At the receiving end, a test set measures the level of the received tone in dBm. A test set measures the total signal power on the line (tone plus noise power), but since the noise power is normally 20 dB or more below the tone power, the contribution of the noise power to the total power is insignificant. Following this measurement, a C-notched noise measurement is taken. For this measurement, the test set is configured to read noise (in dBRNC) and the test set inserts a very sharp, notch filter that attenuates the test tone (1004 Hz) by at least 50 dB. As a result, the test set measures only the noise power present on the line while a tone is being transmitted on the line. This reading gives the C-notched noise power in dBRNC. To compute signal-to-C-notched noise ratio, add -90 to the signal power reading (to get power referenced to the same level as the noise power), and take the algebraic difference (in dB) between the converted signal power and the noise power reading. Note that the signal and noise are measured at the same TLP.

Example: A four-wire line has an end-to-end loss of 16 dB. With a 1004-Hz, 0-dBm tone applied to the line, a C-notched noise reading of 38 dBRNC is obtained. What is the line's signal-to-C-notched noise ratio?

Calculate the C-notched noise: 38 +(-90) = -52 dBm

Signal-to-C-notched noise ratio is: -16 -(-52) = 36 dB

(6) Signal-to-C-notched noise ratio is one of the primary indicators of overall line performance, particularly for data lines. For any particular modem modulation scheme, there is a minimal signal-to-noise ratio that must be maintained in order to prevent bit errors. As signal-to-C-notched noise ratio decreases, modems will begin to have bit errors, with the error rate increasing as the ratio decreases.

(7) Poor signal-to-C-notched noise ratio can be the result of several problems. The ratio may be low because the received signal is low, due to excessive line loss. Net loss can be checked to determine if this is the source of the problem. If net loss is not excessive, poor signal-to-C-notched noise ratio may be due to excessive noise. For lines transmitted via analog equipment, excessive C-notched noise may be due to excessive idle channel noise. If idle channel noise is normal, excessive C-notched noise may be caused by excessive distortion of the signal. Any distortion of the 1004-Hz test tone

causes signal energy to appear at harmonics of 2 kHz and 3 kHz, which is not removed by the notch filter. This cause of poor signal-to-C-notched noise ratio can be verified by performing a check of the line's intermodulation distortion. For lines transmitted via digital equipment, poor signal-to-C-notched noise is most likely due to excessive distortion of the signal, either due to input levels to the channel bank line card being too high, or possibly due to failures in the analog line on the channel bank line card at either end. A poor signal-to-C-notched noise ratio may also be caused by introducing the signal at too low a level.

(8) As an example, assume a voice frequency (vf) line that has a constant level of white noise from 300 Hz to about 3000 Hz. If a noise level reading is taken with no filter inserted, there will be some noise level, say 30 dBRN. If a C-message filter is inserted, the meter reading will drop by 1.5 dB, resulting in a noise reading of 28.5 dBRNC. Note, however, that the 1.5 dB is not a constant or conversion factor between dBRN and dBRNC, although many references make it sound as such. The difference between a noise reading in dBRN and dBRNC can vary greatly depending on the characteristic of the noise spectrum. If it is a vf line with a heavy concentration of noise in the midband, say from 1 kHz to 2 kHz, the reading in dBRN and dBRNC might not be different at all. If, however, it is a vf line with most of the noise power at very low frequencies, say 300 to 500 Hz, the difference between the reading with and without the C filter could be 5 dB or more. 0 dBRNC is considered to be equal to -90 dBm. Thus, when it is necessary to convert the power of a test tone from dBm to dBRN or dBRNC for computation of a signal-to-noise ratio, the conversion factor is 90.

d. Noise. Idle channel noise is the total ambient power that exists on a voice frequency line. To ensure that no input signals are present, the input to the line is terminated in the line's characteristic impedance, which is normally 600 Ω. With the input terminated, the total ambient power is measured at the output. This ambient power level could be measured in dBm, just as signals and test tones are measured, but this would normally give a very large negative number. To avoid this, noise power is normally measured using dBRN, which is the power level in dB relative to the reference noise level of -90 dBm or 1 picowatt. This noise power level indicates the total noise power in the line. As a better indicator of potential for interference with traffic on the line, the noise level is normally measured through a C-message filter. This filter attenuates noise near the upper and lower frequency limits of the vf passband, since noise near the edges of the band does not impair line performance as much, both for voice and data usage. When the line noise power is measured through a C-message filter, the level is expressed in dBRNC.

(1) Excessive noise can obviously interfere with the desired intelligence on a line and is also a substantial distraction to the user when signals are not present. For voice usage, excessive noise can cause words or conversation to be unintelligible. For data usage, the excessive noise is added to the modulated carrier, and appears as noise on the demodulated output, which can result in bit errors if the noise level is too high.

(2) For lines transmitted via analog equipment, the idle channel noise on a line is normally the result of inherent noise existing at amplifier inputs combined with noise induced from external sources. Excessive noise can be the result of faulty amplifiers or transmission equipment (e.g., microwave radio), or excessive pick-up of electromagnetic interference (EMI), either due to a new or increased source of EMI, or due to an improper or failed grounding and/or shielding of equipment. When analog lines are transmitted by digital transmission media, idle channel noise is normally caused by quantizing.

(3) Phase and gain hits are transient noise phenomena that are classified as abrupt changes in the phase or amplitude of a received signal's sinusoidal wave. These noise spikes have a low value of energy per pulse but because of their short time duration and high peak amplitude, they can interfere with the signal. A noise spike is considered impulse noise if it lasts less than 4 milliseconds. The counting thresholds established for measuring these phenomena are set at levels that just cause data modem errors.

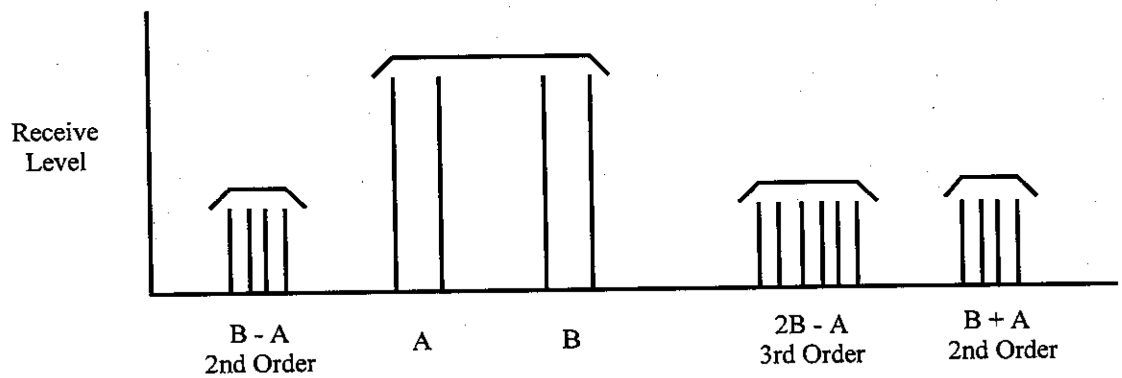
e. Intermodulation Distortion (IMD). This is a measure of distortion resulting from the line having an output characteristic that is not a perfectly linear reproduction of the input signal.

(1) The telecommunications industry has adopted intermodulation distortion (IMD) as the standard method to check for nonlinear line performance. If two tones are applied to a line that is nonlinear, the output will contain not only harmonics of the original tones, but signals at frequencies that are combinations of the two input frequencies. These signals are called intermodulation products. The standard IMD test transmits four tones: an A pair, 6 Hz apart, centered at 860 Hz; and a B pair, 16 Hz apart, centered at 1380 Hz. The four tones are all sent at the same level, and the transmission level set on the test set (e.g., -13 dBm) is the power level of the composite signal of the four tones. At the receive end, the test set monitors for second and third order intermodulation products. The second order products are B-A centered at 520 Hz and B+A centered at 2240 Hz. The signal power in these products is monitored by narrow passband filters that prevent idle channel noise from contributing to the reading. The third order product is 2B-A, centered at 1900 Hz, which is also monitored through a narrow passband filter. The test set displays the level of the intermodulation products relative to the level of the composite four-tone test signal. As an example, if the level of the test signal being received is -13 dBm, and the second order IMD is measured as -32 dB, this indicates that the total power of the second order intermodulation products measured was -45 dBm. Figure 2-5 depicts the IMD products.

(2) Nonlinear distortion is generally not critical to lines used for voice traffic. Distortion levels would have to be very high to impair conversation. For data traffic, however, particularly for modems that use sophisticated modulation schemes to send very high data rates, nonlinear distortion can cause bit errors.

(3) Excessive IMD is most often due to distortion in signal amplifiers but can also occur if signal levels applied to an amplifier are too high.

FIGURE 2-5. INTERMODULATION DISTORTION PRODUCTS



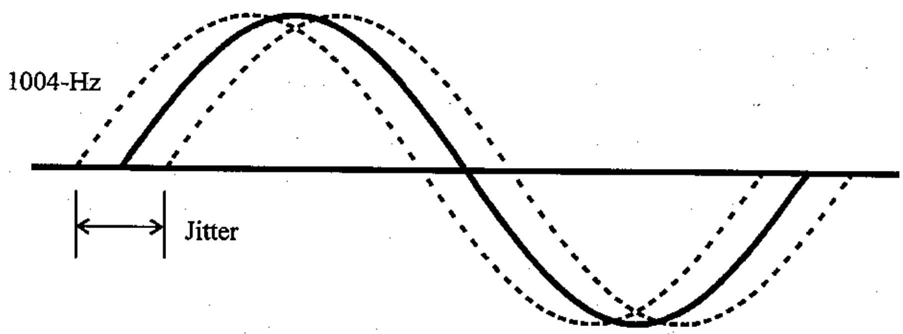
f. Envelope Delay Distortion. This parameter is also sometimes referred to as group delay distortion. It is a measure of how much a signal is distorted due to variations in the time it takes for different frequencies in the vf passband to travel between two points. To measure envelope delay, the transmit test set amplitude modulates, in turn, frequencies within the band of interest. The test set at the far end receives the amplitude modulated carrier and demodulates it to recover the modulating tone. This recovered tone is then used to modulate a fixed-frequency carrier (normally 1804 Hz), which is transmitted back to the test set at the transmit end. The transmit end test set receives the 1804-Hz carrier and demodulates it to recover the modulating tone. The phase of this recovered tone is then compared to the phase of the oscillator used to generate the original modulating tone. Based on the phase difference between the oscillator generating the modulating tone and the recovered tone, the test set at the transmit end displays a delay, normally in microseconds (μs), which is the time it took the signal to travel to the far end and return. As different frequencies are selected, the test set at the transmit end changes the frequency of the carrier used to transmit the modulating tone. The modulating tone is always returned to the transmit end, however, using the same 1804-Hz carrier. As a result, the return time is always the same. Any change in the round-trip delay as the frequency is changed is due to variations in propagation time of the signal from the transmit end to the far end. Once the absolute envelope delay times have been measured for several frequencies across the band of interest, envelope delay distortion is determined by taking the difference between the longest and the shortest delay times. For example, if all frequencies had the same absolute delay time, envelope delay distortion would be zero, since all frequencies in the band of interest propagate through the line in the same amount of time.

(1) Envelope delay distortion is normally not a problem with lines used for voice communications only. Excessive envelope delay, however, can cause data lines to experience errors. If all the frequencies in the spectrum of a modulated carrier do not arrive at the far end at the same time, the carrier received at the far end is distorted due to the phase shift between the different frequencies that make up the carrier.

(2) Excessive envelope delay is normally the result of problems in vf passband filters, whether the line is transmitted via analog or digital equipment. In order to prevent interference with other lines (analog equipment) when the signal is sampled by the a/d converter (digital equipment), the vf signal applied to a transmission system is normally passed through filters that limit the passband to 300 to 3000 Hz or something similar. In addition to attenuating signals near the edge of the passband, filters also tend to slow down signals near the edge of a passband. Most of the envelope delay seen on a vf line is normally due to these passband filters. Normally, there is no provision to adjust such filters, so excessive envelope delay distortion is corrected by replacing the line card or module that has the bad filter on it. Note also that envelope delay is cumulative. For example, assume that a vf line goes from point A to point B via a T1 line. At point B, the vf line (in analog format) is patched to another T1 line and sent to point C. Each pass through a channel bank line card (which has vf passband filters on the transmit and receive side of the analog portion of the card) contributes additional envelope delay distortion to the signal. Thus, the envelope delay distortion measured from point A to point C for this line would be about twice as bad as the delay distortion measured from either A to B or from B to C.

g. Phase Jitter. Phase jitter is any variation in the phase of a signal, as shown in figure 2-6. This parameter measures the ability of a line to accurately reproduce the phase of an input signal. As an example, assume a 1004-Hz tone is applied to a line. At the far end, a frequency counter verifies that the output signal is precisely 1004 Hz. Thus, the line is accurately reproducing the input frequency. As a check on the phase of the output signal, however, assume that the output signal and the output of a precise 1004-Hz oscillator are put in to a phase comparator that indicates the phase difference between the

FIGURE 2-6. PHASE JITTER



two inputs. Since both inputs are the same frequency, the average phase difference must be zero. The instantaneous phase difference, however, may not be zero, and may vary back and forth between positive and negative values. Phase jitter is normally specified in degrees peak-to-peak. As an example, if the test set indicates that the jitter is 10 degrees, the phase difference between the line output and a precision oscillator is varying back and forth between +10 and -10 degrees. Jitter test sets also normally measure jitter over a specified bandwidth. Twenty to 300 Hz is a bandwidth commonly used to measure jitter since that band encompasses the 60-Hz power frequency that often interferes and causes jitter on communications lines. This means that the output of the phase comparator is passed through a filter that eliminates phase jitter less than 20 or more than 300 Hz before the peak-to-peak jitter is measured.

(1) Jitter is not a problem on lines used for voice communication only. For lines used to send data, however, excessive jitter can cause bit errors.

(2) Jitter is most often caused by interference from 60-Hz power sources. Common sources of jitter a ripple on power supply voltages and pickup of 60 Hz in areas where cabling runs near 60-Hz power distribution.

h. Impulse Noise. This parameter monitors for intermittent strong pulses of noise or interference. To measure impulse noise, a test set is connected to measure the noise on a line. A threshold noise level is set on the test set. Any time the measured noise level goes above this level, the test set will increment a counter that is initially set to zero. While noise pulses can be counted for any length of time, a period of 15 minutes is normally used. At the end of 15 minutes, the counter reading on the test set indicates the total number of noise pulses received that exceeded the threshold setting during the 15-minute (or other period) interval.

(1) Low amounts of impulse noise are normally insignificant on lines used for voice only. Frequent occurrences of relatively high noise pulses, however, can make conversation difficult to understand. For data lines, noise pulses can cause bit errors. As a general rule, the more sophisticated the modulation scheme used to transmit data, the lower the level of noise pulses that can cause bit errors.

(2) For lines transmitted via analog or digital equipment, impulse noise is most often the result of interference picked up from outside sources. As an example, switching heavy electrical machinery on and off can induce noise spikes in analog lines if the analog lines are in the vicinity of power lines supplying the machinery. Spikes on commercial power systems, which can have any number of sources, can cause spikes of noise on analog lines if equipment power supplies do not have adequate filtering and isolation from commercial power. Sources of impulse noise can be very difficult to isolate, particularly when the noise does not occur with any regularity. Possible insight to sources can sometimes be gained by monitoring trends in impulse noise activity as a function of different times of the day, days of the week, changing weather conditions, or changes in operation or configuration of other electrical/electronic equipment at a site.

i. Peak-to-Average Ratio (P/AR). P/AR is a only a quick benchmark test designed to give a reliable yet simple measure of a voice frequency line's overall bandwidth and phase nonlinearity and therefore its ability to effectively transmit high speed data traffic. To conduct this test, the test set at the sending end applies to the line under test a standard test signal that consists of a special combination of 16 individual tones. The frequencies and relative levels of these tones are selected so that the composite signal is a relatively high frequency carrier, the amplitude of which rapidly varies between zero and a peak value. At the receiving end, the test set monitors both the average and the instantaneous power of the received composite signal. The test set then computes the ratio of the peak value of the instantaneous power to the average power measured. This ratio is compared to the ratio of an undistorted P/AR test signal. If the ratio was unchanged by passing through the line under test, the test set will indicate a received P/AR of 100 units. In general, however, distortion in the line will cause the ratio of the peak power to the average power received to be less than the original test signal. A received P/AR of 50, for example, indicates that the received peak power to average power ratio is half that of the undistorted test signal.

(1) P/AR is not a measure of any one performance parameter, but is a general measure of overall line performance. The absolute value of P/AR is not as

significant as is the amount by which it changes with time. P/AR is most directly affected by attenuation distortion, intermodulation distortion, and envelope delay distortion. A significant degradation in any (or more than one) of these parameters will result in a reduction in measured P/AR. P/AR is normally measured at an initial acceptance, and that value retained for future reference. When problems with a line are suspected, a P/AR check can then be performed. If P/AR has not changed more than a few units from the original value measured at acceptance, it is unlikely that there has been any significant degradation in any of the line's parameters. If an unusually low P/AR is measured, the other individual performance parameters of the line must be measured to determine the specific cause of the degraded P/AR.

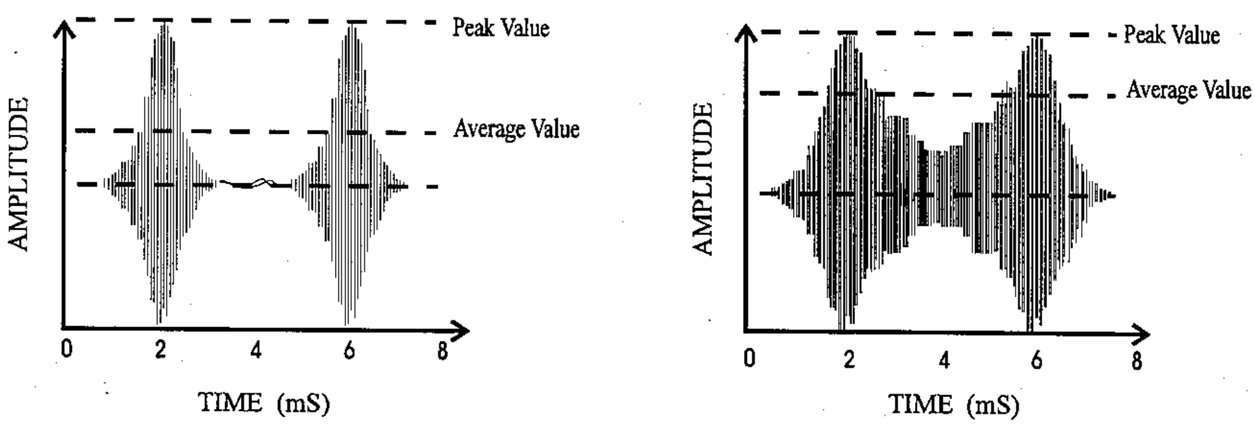
(2) The P/AR signal (shown in figure 2-7a) is a signal whose frequency components are spread out across the voice frequency bandwidth and so configured as to resemble a series of data pulses. After passing through a disruptive medium such as a telephone line, various types of interference might cause changes in the waveform. As can be seen in Figure 2-7b, the ratio of peak voltage to the average voltage changes according to the degree of interference.

(3) There is a high correlation between measured P/AR values and the values calculated from a plot of envelope delay distortion. In fact, for an envelope delay response containing significant ripples, P/AR is a better indication of the transmission path's ability to reliably pass data.

(4) Noise can also have a significant effect on P/AR measurements. (See figures 2-8a and b.) Due to the effect of noise it is important to measure signal-to-noise ratio before making the P/AR measurement. If the signal-to-noise ratio is less than 25 dB, the P/AR reading will be significantly reduced by noise alone.

(5) Nonlinear (intermodulation) distortion can similarly affect the P/AR reading. The effect depends on whether the second or third order products dominate as the source of distortion. If the third order products dominate, they increase or decrease the P/AR value depending on the sign of the added products.

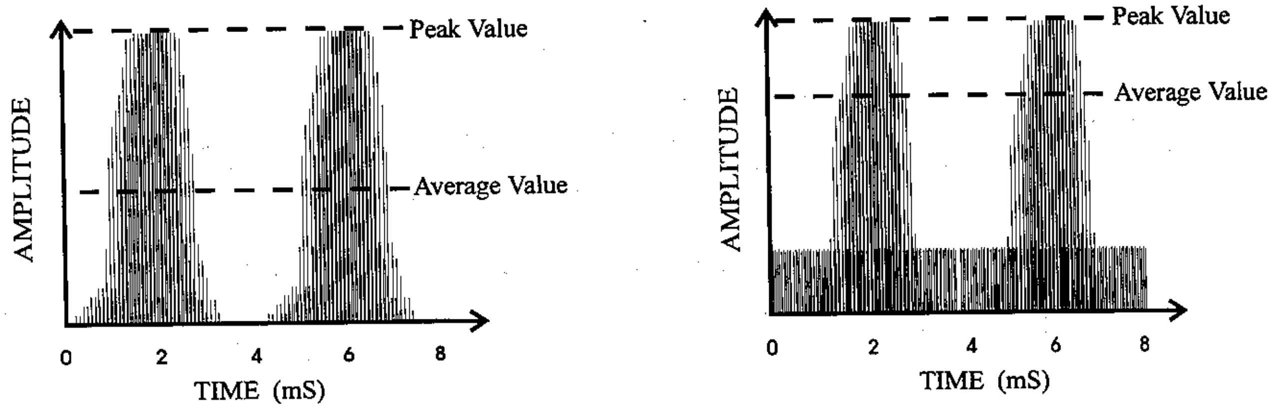
FIGURE 2-7. P/AR CHANGES ON A TYPICAL LINE



a. The P/AR signal as transmitted

b. P/AR after going through line

FIGURE 2-8. EFFECTS OF NOISE ON P/AR



a. P/AR with no noise

b. P/AR signal in the presence of high noise levels

231. In-Service Monitoring.

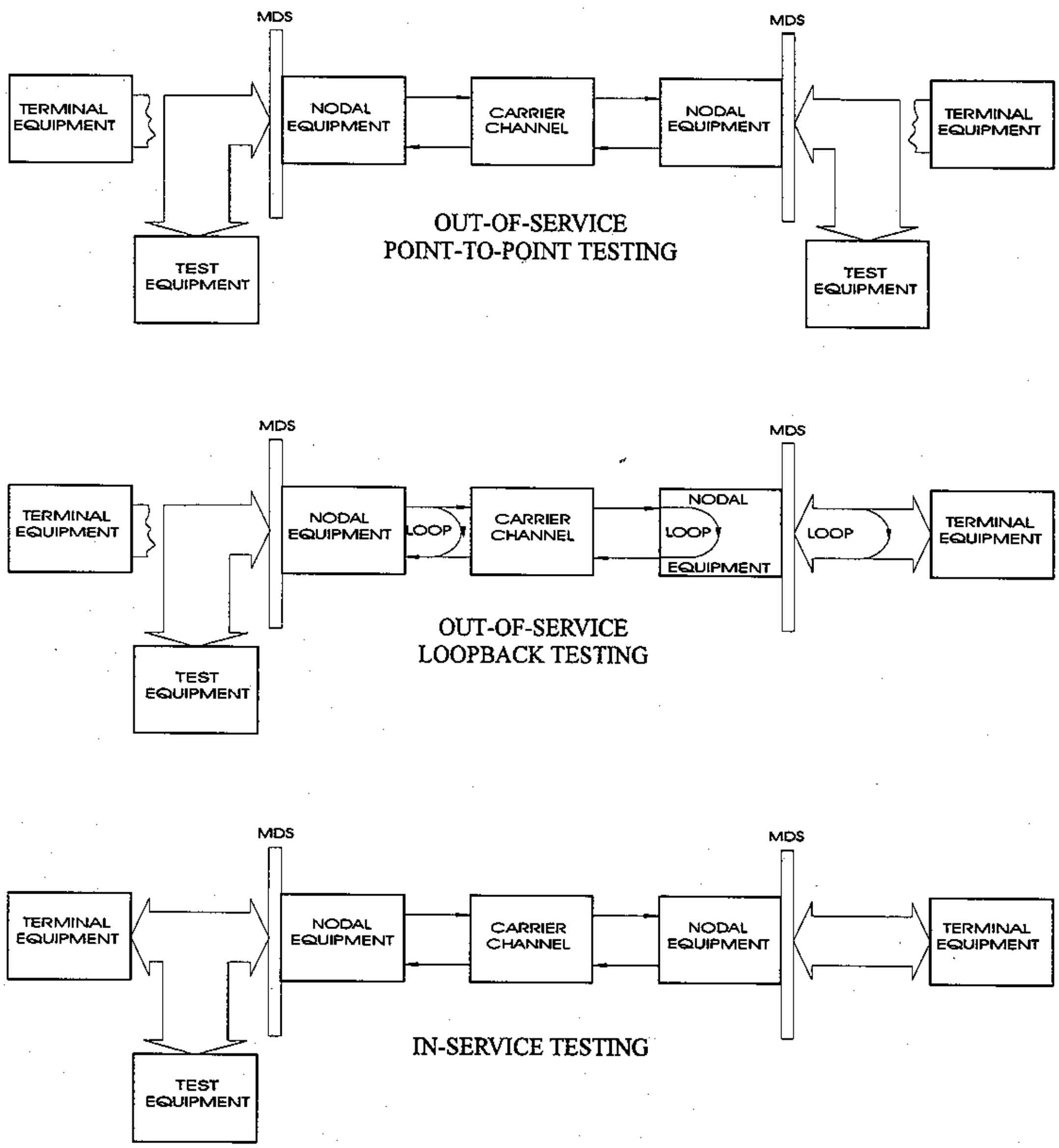
a. Monitoring with Standard Test Equipment. The in-service method allows live lines to be monitored at various access points without disturbing traffic. Thus in-service monitoring that does not disrupt traffic is more suitable for routine monitoring than out-of-service testing. Additionally, in-service monitoring indicates performance under actual operating conditions. The primary disadvantage of in-service monitoring is that its measurements are not as precise as those available with out-of-service testing. Also, some network equipment may not support in-service monitoring activities. See figure 2-9 for typical layouts for in-service and out-of-service testing. LINCS and DMN are equipped for, and employ, in-service monitoring throughout the FAA. In some locations and on selected services, the remote maintenance adaptable concentrator (RMAC) provides a capability to monitor leased lines so that a total or intermittent loss of transmission is recorded and identified as a maintenance alert to AF personnel.

b. Monitoring LINCS Lines with the Newbridge 4602 Network Management System (NMS).

(1) The status of all LINCS lines (including analog lines) is monitored on a real-time basis at the LINCS network management centers using the Newbridge 4602 NMS, manned by MCI for the FAA LINCS program. A Newbridge 4602 view-only workstation, called the system status display (SSD), is installed at designated FAA locations which allows these sites to view those lines that are on the LINCS backbone. Procedures for using the Newbridge 4602 SSD are discussed in chapter 5, paragraph 510. A typical configuration of the 4602 display system is shown in figure 2-10.

(2) These FAA system status display workstations provide monitor-and-display capabilities only, and do not support network configuration changes, or commands to perform remote diagnostic tests. (The Newbridge 4602 Network Management System at the MCI LINCS network management center has the more powerful software and additional hardware that allows them to perform network provisioning, monitoring, and configuration changes, as well as remote diagnostic testing.) The purpose of the view-only workstation is to provide its network map, which graphically depicts the configuration of the LINCS network elements and uses

FIGURE 2-9. TYPICAL IN-SERVICE AND OUT-OF-SERVICE TESTING



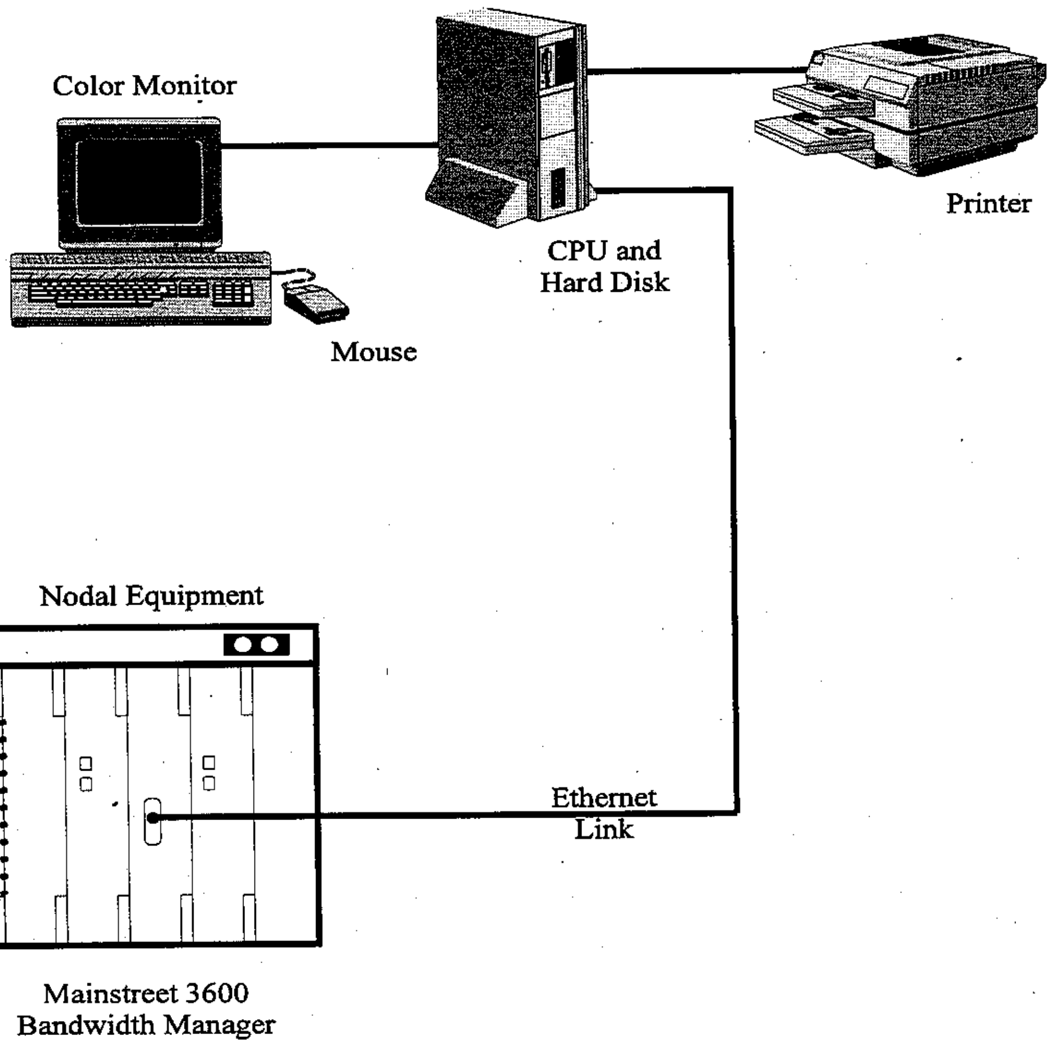
color to indicate their operational status. The 4602 SSD also has the capability to view LINCS trouble tickets.

(3) When performance of network elements falls below specified thresholds, and these elements therefore are declared unavailable, the system status display automatically updates display presentations (change in path or icon color) to reflect current status. The operator is automatically presented with a graphic display of the network configuration using different icons to represent

end-user location A (EUL-A) multiplexer nodes, EUL-B channel banks, backbone transmission paths, and individual user channels. Successive levels of graphic detail are provided as the operator zooms in on an icon. Within the equipment of EUL sites, individual cards, equipment bays, or modules can be displayed. All configuration icons are color coded to display status: normal operation, degraded performance, service failure (unavailable), or out-of-service to maintenance (unavailable). Changes in color correspond to changes in network element status.

(4) For VG-6 lines, the Newbridge 4602 uses a 3250-Hz tone to allow it to monitor status of analog lines. For VG-8 lines, the Newbridge 4602 monitors the data stream transmitted by the FAA modems.

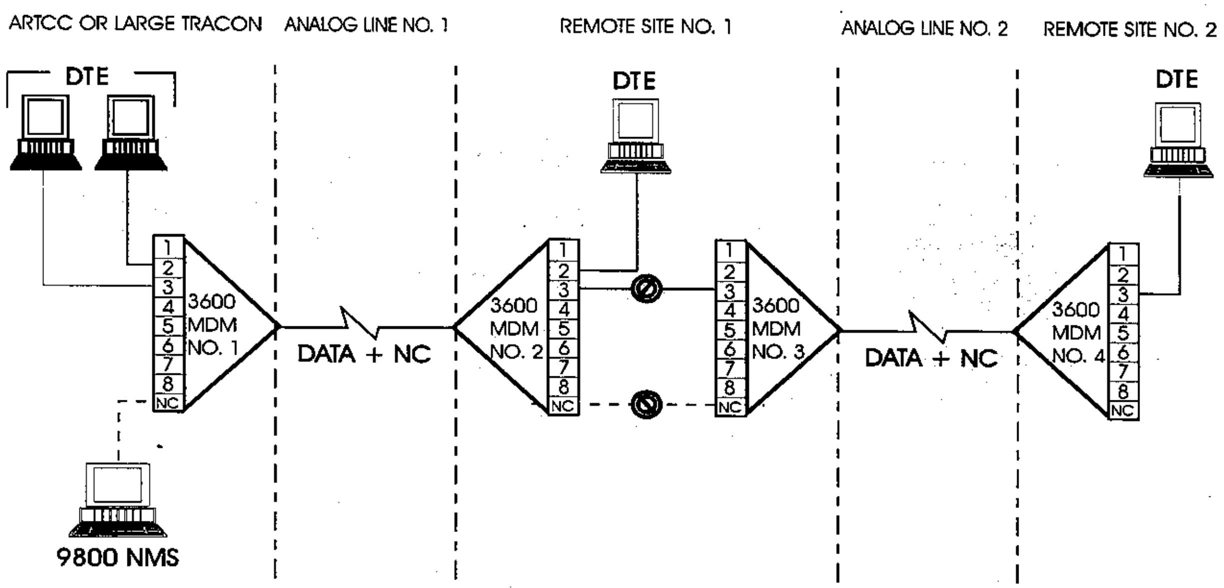
FIGURE 2-10. 4602 NMS VIEW-ONLY MONITORING SYSTEM



c. **DMN Monitoring.**

(1) The Data Multiplex Network (DMN) uses the Codex 9800 network management system (NMS) to provide full-period monitoring of the analog lines carrying data from the Codex 3600 modems. Refer to figure 2-11. The modem analyzes its received carrier to determine impairments generated by the line. These impairments include line loss (in the form of received signal level), signal-to-noise ratio, impulse hits, phase jitter, frequency offset, and harmonic distortion. Values for these impairments are sent from the modem to the 9800 NMS via the network channel, where they are compared to threshold values previously entered by the

FIGURE 2-11. CODEX 9800 NETWORK MANAGEMENT SYSTEM



NOTE: Performance of analog line no. 1 is monitored by modems no. 1 and no. 2. Performance of analog line no. 2 is monitored by modems no. 3 and no. 4. Performance parameters of both lines are provided to the 9800 NMS via the network channel.

DMN system administrator. These thresholds are specified in Order 6170.10, Maintenance of Data Multiplexing Network Equipment. If the value of any of the impairments exceeds the threshold entered the 9800 NMS will sound an alarm, print out an alarm event, and display the line in red. The 9800 NMS also has the capability to provide a snapshot of the line. This is a display of impairment values as they are at a given moment. Trend testing of the line may be accomplished using the 9800 NMS as it will store impairment values at periodic intervals and provide statistical analyses of the data gathered. In this way, the specialist can tell if a line is degrading to a catastrophic event.

(2) The 75 bits per second network channel carries control and status information from the modems to the 9800 NMS. The operation of this channel is such that analog lines used for tail circuits, where neither of the modems is collocated with the 9800 NMS, may still be monitored by the 9800 NMS.

232.-299. RESERVED.

CHAPTER 3. STANDARDS AND TOLERANCES

300. GENERAL. This chapter prescribes the standards and tolerances for leased and FAA-owned analog lines. The terms used are defined and described in Order 6000.15 or in the glossary of this order. Key performance parameters are identified by an arrow(→) placed in the left margin. The line characteristics for commercial leased lines in this order are extracted from the LINCS contract, Bellcore Technical Reference TR-TSY-000335, Issue 2, May 1990; and FCC Tariff Number 9. Additional types of commercial leased lines that regions may obtain from local telephone companies might require a regional supplement to this order.

301. NOTES AND CONDITIONS. The following describes the requirements, variances, and/or test limits to be considered when applying the values listed in the standards and tolerances.

a. The maximum power for test tones on FAA analog lines is established as -13 dBm at the zero TLP. (See paragraph 203d(1).)

b. On LINCS VG-6 lines, MCI uses a 3250-Hz tone for network monitoring; do not transmit a test tone within 50 Hz of that frequency (for VG-8 lines, MCI monitors the data stream transmitted by FAA data modems. Since MCI uses the data stream for monitoring, the FAA MUST contact the MCI NMC prior to performing any line or modem testing that will disrupt the data stream). On all lines, care should be exercised to avoid transmission of a test tone on a vendor's loop-back frequency. These frequencies are exempted from measurements.

c. In the standards and tolerance tables, parameters that apply only to lines used exclusively in data applications are indicated by a footnote.

d. The plus sign (+) in the tolerance/limits columns indicates more loss than the 1004-Hz reference loss. The minus sign (-) indicates less loss than the 1004-Hz reference loss. For example, if the 1004-Hz reference loss for a line being tested was 14 dB, and the tolerance/limit is stated as +5, -1 dB, the line will be out of tolerance if its attenuation for that frequency is outside the limits of 19 to 13 dB. The ALTE can normalize frequency attenuation measurements with respect to 1004 Hz and provide a direct reading in terms of + or - dB from 1004 Hz.

e. Standards and tolerances/limits:

(1) Each essential system, subsystem, and equipment performance parameter has been assigned a standard value that is usually the optimum value from a systems engineering viewpoint. These standard values are compatible with the system as a whole and the design capability of the equipment involved. In addition, each parameter (standard value) has been assigned an initial and an operating tolerance/limit expressed in terms of permissible deviation from the standard or in absolute maximum and/or minimum performance levels, as appropriate, for use during maintenance and certification activities.

(2) The terms standard, initial, and operating tolerances/limits are defined as follows:

(a) The *standard* is the optimum value assigned to a parameter of the system and is compatible with the system as a whole and the design capability of the equipment involved.

(b) The *initial tolerance/limit* is the maximum deviation from the standard value of the parameter, or range, permissible when the system or equipment is accepted for use in the National Airspace System at the time of initial commissioning, or after any readjustment, restoration (other than after a cable cut), modification, or modernization.

(c) The *operating tolerance/limit* is the maximum deviation from the standard value of the parameter or the range within which a system or equipment may continue to operate on a commissioned basis without adjustment or corrective maintenance and beyond which remedial action by maintenance personnel is mandatory.

(3) In summary, the above FAA guidance is that maintenance personnel should, when there is any degree of adjustment available, strive to attain the standard values for all analog lines but accept a line that achieves performance within the values specified for the initial tolerance/limits.

f. The capability of remote maintenance monitoring (RMM) systems being installed at different facilities varies with facility type. The ability to do part or all of the performance checks from a remote location does not alter the required periodic maintenance interval nor reduce the number of parameters to be checked. If the capability exists to check one or more parameters from a remote location, it is acceptable to check those parameters remotely.

g. This chapter lists standards and tolerances for the line types (VG-6 and VG-8) provided by the Leased Interfacility NAS Communications System (LINCS). In addition to standard two-point analog lines, LINCS also provides multipoint lines. For multipoint lines, these standards and tolerances are applicable to each pair of access points to a multipoint line. As an example, if a multipoint line extends from facility A to facility B and on to facility C, the standards and tolerances provided herein apply to line performance between A and B, between B and C, and between A and C.

h. Looped parameters. Refer to paragraph 505c for information on adjusting the tolerance values of parameters when line performance is measured in a looped mode vice end-to-end.

i. Local FAA authorities may accept new leased lines from the vendor without requiring FAA qualified personnel to conduct separate line runs if ALL the following conditions are met:

(1) The vendor's tests are witnessed by qualified personnel who are able to judge satisfactory results.

(2) The vendor provides a copy of their test data demonstrating satisfactory test results (meets or exceeds established line parameters).

(3) The line is under real-time monitoring before and after being placed in operational status.

(4) For voice multipoint lines, the user performs functional checks of voice and signaling to ensure satisfactory operation with end points and technicians review vendor test results which confirm line parameters to be within acceptable tolerances. For data multipoints, the user performs functional checks to ensure satisfactory data communications with all end points and technicians review vendor test results.

(Qualification of FAA or FAA contract personnel to witness testing may be determined by the System Management Office (SMO) manager.)

j. Test results for site records may be on either FAA Form 6000-14 or test equipment hardcopy printouts. Hardcopy results may be generated either by the contractor (with qualified technicians witnessing) or by FAA personnel using the Automated Line Test Equipment (ALTE).

302. RESERVED.

Parameter	Reference Paragraph	Standard	Tolerance/Limit	
			Initial	Operating
303. LINCS VOICE GRADE 6 (VG-6).	512, 513, 514, 515			
→ **a. 1004-Hz net loss**		0 dB	±1.5 dB	Same as initial
→ **b. Attenuation distortion.**				
(1) 304 - 3004 Hz		1004-Hz net loss	-1, +5 dB	Same as initial
(2) 404 - 2804 Hz		1004-Hz net loss	-1, +4 dB	Same as initial
(3) 504 - 2504 Hz		1004-Hz net loss	-1, +3 dB	Same as initial
→ **c. Signal-to-C-notched-noise ratio**		32 dB	≥30 dB	Same as initial
→ **d. Intermodulation distortion[1].**				
(1) Second order		35 dB	>33 dB	Same as initial
(2) Third order		42 dB	>40 dB	Same as initial
→ **e. Envelope delay distortion[1] (804 - 2604 Hz)**		≤650 μsec	≤700 μsec	Same as initial
→ **f. Phase jitter[1].**				
(1) 4 - 300 Hz		9°	<10°	Same as initial
(2) 20 - 300 Hz		4°	<5°	Same as initial
→ **g. Impulse noise at threshold noted[1]**		No more than 15 counts in 15 min. (at 65 dBRNC0)	No more than 15 counts in 15 min. (at 67 dBRNC0)	Same as initial
h. P/AR		Commissioned value	±4 units	Same as initial
304. LINCS VOICE GRADE 8 (VG-8).	512, 513, 514, 515			
→ **a. 1004-Hz net loss**		0 dB	±1.5 dB	Same as initial
→ **b. Attenuation distortion.**				
(1) 304 - 3004 Hz		1004-Hz net loss	-1, +5 dB	Same as initial
(2) 404 - 2804 Hz		1004-Hz net loss	-1, +2 dB	Same as initial
→ **c. Signal-to-C-notched-noise ratio**		34 dB	≥32 dB	Same as initial
→ **d. Intermodulation Distortion[1].**				
(1) Second order		46 dB	>45 dB	Same as initial
(2) Third order		49 dB	>48 dB	Same as initial

[1]Parameters apply to lines used exclusively in data applications.

Parameter	Reference Paragraph	Standard	Tolerance/Limit	
			Initial	Operating
→ e. **Envelope delay distortion**[1]................ **(804 - 2604 Hz)**		≤650 µsec	≤700 µsec	Same as initial
→ f. **Phase jitter**[1].				
(1) 4 - 300 Hz..................................		8°	<9°	Same as initial
(2) 20 - 300 Hz................................		3°	<4°	Same as initial
→ g. **Impulse noise at threshold noted**[1].....		No more than 15 counts in 15 min. (at 65 dBRNC0)	No more than 15 counts in 15 min. (at 67 dBRNC0)	Same as initial
h. **P/AR**..		Commissioned value	±4 units	Same as initial
305. FTS2000.	512, 513, 514, 515			
→ a. **1004-Hz net loss**............................		0 dB	-2, +2.5 dB	Same as initial
→ b. **Attenuation distortion.**				
(1) 304 - 3004 Hz............................		1004-Hz net loss	-3, +12 dB	Same as initial
(2) 404 - 2804 Hz............................		1004-Hz net loss	-2, +6 dB	Same as initial
→ c. **Signal-to-C-notched-noise ratio**........		≥28 dB	Same as standard	Same as standard
→ d. **Intermodulation distortion**[1].				
(1) Second order...............................		≥45 dB	Same as standard	Same as standard
(2) Third order.................................		≥43 dB	Same as standard	Same as standard
→ e. **Envelope delay distortion**[1]................ **(804-2604 Hz)**		≤1250 µsec	Same as standard	Same as standard
→ f. **Phase jitter**[1].				
(1) 4 to 300 Hz................................		<12°	Same as standard	Same as standard
(2) 20 to 300 Hz..............................		<8°	Same as standard	Same as standard
→ g. **Impulse noise at threshold noted**[1].....		No more than 15 counts in 15 min. (at 71 dBRNC0)	Same as standard	Same as standard
h. **P/AR**[2]..		Commissioned Value	±4 units	Same as initial

[1]Parameters apply to lines used exclusively in data applications.
[2]P/AR for FTS2000 is a non-tariffed item for use only within the FAA and is based on industry guidelines.

Parameter	Reference Paragraph	Standard	Tolerance/Limit Initial	Tolerance/Limit Operating
306. RCL AND LDRCL VF LINES VIA ANALOG MULTIPLEX.	512, 513, 514, 515			
→ **a. 1004-Hz net loss.**				
(1) When not part of a composite line[1]..		0 dB	±1.5 dB	Same as initial
(2) When part of a composite line[1].......		0 dB	±4 dB	Same as initial
→ **b. Attenuation distortion.**				
(1) 304 - 3004 Hz..............................		1004-Hz net loss	-1, +3 dB	Same as initial
(2) 404 - 2804 Hz..............................		1004-Hz net loss	-1, +1.5 dB	Same as initial
→ **c. Signal-to-C-notched-noise ratio.......**		34 dB	≥32 dB	Same as initial
→ **d. Intermodulation distortion[2].**				
(1) Second order................................		46 dB	≥45 dB	Same as initial
(2) Third order..................................		49 dB	≥48 dB	Same as initial
→ **e. Envelope delay distortion[2]................ (804-2604 Hz)**		≤400 µsec	Same as standard	Same as standard
→ **f. Phase jitter[2]...................................... (1 kHz tone)**		<3°	Same as standard	Same as standard
→ **g. Impulse noise at threshold noted[2].....**		No more than 15 counts in 15 min. (at 65 dBRNC0)	No more than 15 counts in 15 min. (at 67 dBRNC0)	Same as initial
h. P/AR..		Commissioned value	±4 units	Same as initial
307. RCL AND LDRCL VF LINES VIA DS-1 CHANNEL BANK.	512, 513, 514, 515			
→ **a. 1004-Hz net loss.**				
(1) When not part of a composite line[1]..		0 dB	±1.5 dB	Same as initial
(2) When part of a composite line[1].......		0 dB	±4 dB	Same as initial
→ **b. Attenuation distortion...................... (404-2804 Hz)**		1004-Hz net loss	±1.5 dB	Same as initial
→ **c. Signal-to-C-notched-noise ratio.......**		34 dB	≥34 dB	Same as initial

[1]A line is composite when it is brought down to voice frequency level and then sent over another line segment at voice frequency level. An RCL/LDRCL line that is a segment of a composite line has less stringent loss tolerance to allow adjustment to meet the overall requirement of the composite line.
[2]Parameters apply only to lines used exclusively in data applications.

Parameter	Reference Paragraph	Standard	Tolerance/Limit Initial	Tolerance/Limit Operating
→ **d. Intermodulation distortion[1].**				
(1) Second order..................................		45 dB	≥45 dB	Same as initial
(2) Third order..................................		48 dB	≥48 dB	Same as initial
→ **e. Envelope delay distortion[1]................ (804-2604 Hz)**		≤250 μsec	Same as standard	Same as standard
→ **f. Phase jitter[1].**				
(1) 4 - 300 Hz..................................		8°	<9°	Same as initial
(2) 20 - 300 Hz..................................		3°	<4°	Same as initial
→ **g. Impulse noise at threshold noted[1].....**		No more than 15 counts in 15 min. (at 65 dBRNC0)	No more than 15 counts in 15 min. (at 67 dBRNC0)	Same as initial
h. P/AR..................................		Commissioned value	±4 units	Same as initial
308. OTHER FAA LEASED LINES.	512, 513, 514, 515			
a. Service type 1.				
→ (1) 1004-Hz net loss..........................		Commissioned value	±4 dB	Same as initial
→ (2) Attenuation distortion.				
(a) 304 - 3004 Hz..........................		1004-Hz net loss	-3, +12 dB	Same as initial
(b) 404 - 2804 Hz..........................		1004-Hz net loss	-2, +9 dB	Same as initial
b. Service type 5.				
→ (1) 1004-Hz net loss..........................		Commissioned value	±4 dB	Same as initial
→ (2) Attenuation distortion.				
(a) 304 - 3004 Hz..........................		1004-Hz net loss	-3, +12 dB	Same as initial
(b) 404 - 2804 Hz..........................		1004-Hz net loss	-2, +10 dB	Same as initial
(c) 504 - 2504 Hz..........................		1004-Hz net loss	-2, +8 dB	Same as initial
→ (3) Signal-to-C-notched-noise ratio.....		≥24 dB	Same as standard	Same as standard
→ (4) Intermodulation distortion[1].				
(a) Second order..........................		≥27 dB	Same as standard	Same as standard
(b) Third order..........................		≥32 dB	Same as standard	Same as standard
→ (5) Envelope delay distortion[1]........... (804 - 2604 Hz)		≤1750 μsec	Same as standard	Same as standard

[1]Parameters apply only to lines used exclusively in data applications.

Parameter	Reference Paragraph	Standard	Tolerance/Limit Initial	Tolerance/Limit Operating
→ (6) Phase jitter[1].				
(a) 4 - 300 Hz..................................		<15°	Same as standard	Same as standard
(b) 20 - 300 Hz................................		<10°	Same as standard	Same as standard
c. C-1 conditioned.				
→ (1) Attenuation distortion.				
(a) 304 - 2704 Hz..........................		1004-Hz net loss	-2, +6 dB	Same as initial
(b) 1004 - 2404 Hz........................		1004-Hz net loss	-1, +3 dB	Same as initial
(c) 2704 - 3004 Hz........................		1004-Hz net loss	-3, +12 dB	Same as initial
→ (2) Envelope delay distortion[1].				
(a) 804 - 2604 Hz..........................		≤1750 µsec	Same as standard	Same as standard
(b) 1004 - 2404 Hz........................		≤1000 µsec	Same as standard	Same as standard
d. C-2 conditioned.				
→ (1) Attenuation distortion.				
(a) 304 - 3004 Hz..........................		1004-Hz net loss	-2, +6 dB	Same as initial
(b) 504 - 2804 Hz..........................		1004-Hz net loss	-1, +3 dB	Same as initial
→ (2) Envelope delay distortion[1].				
(a) 504 - 2804 Hz..........................		≤3000 µsec	Same as standard	Same as standard
(b) 604 - 1004 Hz..........................		≤1500 µsec	Same as standard	Same as standard
(c) 104 - 2604 Hz..........................		≤500 µsec	Same as standard	Same as standard
e. C-3 conditioned.				
→ (1) Attenuation distortion.				
(a) 304 - 3004 Hz..........................		1004-Hz net loss	-0.8, +3 dB	Same as initial
(b) 504 - 2804 Hz..........................		1004-Hz net loss	-0.5, +1.5 dB	Same as initial
→ (2) Envelope delay distortion[1].				
(a) 504 - 2804 Hz..........................		≤650 µsec	Same as standard	Same as standard
(b) 604 - 2604 Hz..........................		≤300 µsec	Same as standard	Same as standard
(c) 1004 - 2604 Hz........................		≤110 µsec	Same as standard	Same as standard

[1]Parameters apply only to lines used exclusively in data applications.

Parameter	Reference Paragraph	Standard	Tolerance/Limit Initial	Tolerance/Limit Operating
f. C-4 conditioned.				
→ (1) Attenuation distortion.				
(a) 304 - 3204 Hz		1004-Hz net loss	-2, +6 dB	Same as initial
(b) 504 - 3004 Hz		1004-Hz net loss	-2, +3 dB	Same as initial
→ (2) Envelope delay distortion[1].				
(a) 504 - 604 Hz		≤3000 µsec	Same as standard	Same as standard
(b) 604 - 3004 Hz		≤1500 µsec	Same as standard	Same as standard
(c) 804 - 2804 Hz		≤500 µsec	Same as standard	Same as standard
g. D-1 conditioned.				
→ (1) Signal-to-C-notched-noise ratio		≥28 dB	Same as standard	Same as standard
→ (2) Intermodulation distortion[1].				
(a) Second order		≥35 dB	Same as standard	Same as standard
(b) Third order		≥40 dB	Same as standard	Same as standard
h. D-6 conditioned.				
→ (1) Attenuation distortion (404 - 2804)		1004-Hz net loss	-1, +4.5 dB	Same as initial
→ (2) Signal-to-C-notched-noise ratio		≥32 dB	Same as standard	Same as standard
→ (3) Intermodulation distortion[1].				
(a) Second order		≥45 dB	Same as standard	Same as standard
(b) Third order		≥46 dB	Same as standard	Same as standard
→ (4) Envelope delay distortion[1] (604 - 2804 Hz)		≤1400 µsec	Same as standard	Same as standard
→ (5) Phase jitter[1].		<7°	Same as standard	Same as standard
309. FAA COMPOSITE LINES.	512, 513, 514, 515			
a. Used for interphone service.				
→ (1) 1004-Hz net loss		0 dB	±4 dB	Same as initial
→ (2) Attenuation distortion.				
(a) 304 - 3004 Hz		1004-Hz net loss	-3, +12 dB	Same as initial
(b) 404 - 2804 Hz		1004-Hz net loss	-2, +6 dB	Same as initial

[1]Parameters apply only to lines used exclusively in data applications.

Parameter	Reference Paragraph	Standard	Tolerance/Limit Initial	Tolerance/Limit Operating
→ (3) Signal-to-C-notched-noise ratio.....		≥28 dB	Same as standard	Same as standard
(4) P/AR..........		Commissioned value	±4 units	Same as initial
b. Used for air-to-ground radio circuits.				
→ (1) 1004-Hz net loss..........		0 dB	-2, +3 dB	Same as initial
→ (2) Attenuation distortion.				
(a) 304 - 3004 Hz..........		1004-Hz net loss	-3, +12 dB	Same as initial
(b) 404 - 2804 Hz..........		1004-Hz net loss	-2, +6 dB	Same as initial
→ (3) Signal-to-C-notched-noise ratio.....		≥28 dB	Same as standard	Same as standard
(4) P/AR..........		Commissioned value	±4 units	Same as initial
c. Used for data services at speeds of 9.6 kb/s and below.				
→ (1) 1004-Hz net loss..........		0 dB	±4 dB	Same as initial
→ (2) Attenuation distortion.				
(a) 304 - 3004 Hz..........		1004-Hz net loss	-3, +8 dB	Same as initial
(b) 404 - 2804 Hz..........		1004-Hz net loss	-2, +5 dB	Same as initial
→ (3) Signal-to-C-notched-noise ratio.....		30 dB	≥28 dB	Same as initial
→ (4) Intermodulation distortion[1].				
(a) Second order..........		35 dB	≥33 dB	Same as initial
(b) Third order..........		42 dB	≥40 dB	Same as initial
→ (5) Envelope delay distortion[1].......... (804 - 2604 Hz)		≤650 µsec	≤700 µsec	Same as initial
→ (6) Phase jitter[1].				
(a) 4 - 300 Hz..........		9°	<10°	Same as initial
(b) 20 - 300 Hz..........		4°	<5°	Same as initial
→ (7) Impulse noise at threshold noted[1]...		No more than 15 counts in 15 min. (at 65 dBRNC0)	No more than 15 counts in 15 min. (at 67 dBRNC0)	Same as initial
(8) P/AR..........		Commissioned value	±4 units	Same as initial

[1]Parameters apply only to lines used exclusively in data applications.

Parameter	Reference Paragraph	Standard	Tolerance/Limit Initial	Tolerance/Limit Operating
d. Used for data services at speeds higher than 9.6 kb/s.				
→ (1) 1004-Hz net loss		0 dB	±4 dB	Same as initial
→ (2) Attenuation distortion.				
(a) 304 - 3004 Hz		1004-Hz net loss	-2, +8 dB	Same as initial
(b) 404 - 2804 Hz		1004-Hz net loss	-1, +2 dB	Same as initial
→ (3) Signal-to-C-notched-noise ratio		34 dB	≥32 dB	Same as initial
→ (4) Intermodulation distortion[1].				
(a) Second order		46 dB	≥45 dB	Same as initial
(b) Third order		49 dB	≥48 dB	Same as initial
→ (5) Envelope delay distortion[1] (804 - 2604 Hz)		≤650 μsec	≤700 μsec	Same as initial
→ (6) Phase jitter[1].				
(a) 4 - 300 Hz		8°	<9°	Same as initial
(b) 20 - 300 Hz		3°	<4°	Same as initial
→ (7) Impulse noise at threshold noted[1]		No more than 15 counts in 15 min. (at 65 dBRNC0)	No more than 15 counts in 15 min. (at 67 dBRNC0)	Same as initial
(8) P/AR		Commissioned value	±4 units	Same as initial
310. GROUNDS AND LEAKAGE FAA-owned lines	6950.22, para 32			

[1]Parameters apply only to lines used exclusively in data applications.

311.-399. RESERVED.

CHAPTER 4. PERIODIC MAINTENANCE

400. GENERAL. This chapter establishes the maintenance activities and schedules required for analog lines on a periodic basis. The chapter identifies the performance checks (i.e., tests, measurements, and observations) of normal operating controls and functions, which are necessary to determine whether operation is within established tolerances/limits. The table of performance checks represents the maximum intervals permitted between tasks. (For guidance, refer to the current edition of Order 6000.15, General Maintenance Handbook for Airway Facilities.)

401. FULL PERIOD LINE MONITORING. Periodic maintenance testing is not required on lines for which the FAA has available continuous, real-time monitoring. This type of monitoring is presently available on all lines provided under the LINCS program, and lines used with the Data Multiplex Network (DMN) equipment. On such lines, the network monitoring capability is such that the contractor or FAA is aware of, and able to react to, line deterioration in real time.

402.-406. RESERVED.

SECTION 1. PERFORMANCE CHECKS

Performance Checks	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
407. DAILY. Where installed, check the LINCS system status display (SSD) for alarm icons and outstanding alarm indications for lines within assigned airspace. Review alarm information on the monitor and/or printer. (A daily check of the DMN Network Management System is already required by Order 6170.10.)	--------	510
408. ANNUALLY. (Not Required Where Full-Period Monitoring is Provided).		
a. Measure and record net loss at 1004 Hz.	303 thru 309	512 (ALTE) 514 (Manual)
b. Measure and record attenuation distortion (three-tone slope) and signal-to-C-notched noise ratio. (See notes 1 and 2.)	303 thru 309	512 (ALTE) 514 (Manual)
c. Check for satisfactory transfer to all standby or redundant lines switchable by FAA. (See note 3.)	--------	--------

NOTE 1: The Peak to Average Ratio (P/AR) test may be run in lieu of annual attenuation distortion and signal-to-C-notched noise tests. If P/AR is unsatisfactory, do a complete line run to identify out-of-tolerance parameters.

NOTE 2: Except short-haul lines not involving the serving company's test centers, repeaters, or carrier equipment. Exempted lines are typically found on airports and are short, direct runs between control facilities and remote sites.

NOTE 3: Standby (or redundant) lines are those lines present at an FAA demarc that do not normally carry operational traffic. Standby lines are not vendor-provided diverse paths. In the event of failure of a line carrying operational traffic, the FAA specialist responsible may transfer the traffic to the standby line using manual patching or with FAA-controlled automatic switching.

SECTION 1. PERFORMANCE CHECKS (Continued)

Performance Checks	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
409. AS REQUIRED.		
a. On all FAA leased lines, as part of initial line acceptance, verify all parameters of the particular line as identified in chapter 3. (See note 4.)	303 thru 309	513 (ALTE) 515 (Manual) 516 (Multipoint)
b. Before commissioning a composite line, perform a segment-by-segment check of all parameters listed in chapter 3 for the type of line used for each segment in a composite line. When segment-by-segment tests are satisfactory, run an end-to-end check for the entire line.	303 thru 309	513 (ALTE) 515 (Manual)
c. To revalidate an FAA analog line returned to service after failure:		
(1) Point-to-point lines. Check to ensure that the reported parameter is within the applicable operating tolerance listed in chapter 3. (See note 5.)	303 thru 309	513 (ALTE) 515 (Manual)
(2) Multipoint lines. Perform functional checks to ensure required service is provided.	--------	516
410.-420. RESERVED.		

NOTE 4: Local FAA authorities may accept new leased lines from the vendor without requiring FAA qualified personnel to conduct separate line runs if **ALL** the following conditions are met:

a. The vendor's tests are witnessed by qualified personnel who are able to judge satisfactory results. (Qualification of FAA or FAA contract personnel to witness testing may be determined by the SMO manager.)

b. The vendor provides a copy of test data demonstrating satisfactory test results (meets or exceeds established line parameters).

c. The line is under real-time monitoring before and after being placed in operational status.

d. For voice multipoint lines, users perform functional checks of voice and signaling to ensure satisfactory operation with end points, and technicians review vendor test results which confirm line parameters to be within acceptable tolerances. For data multipoints, users perform functional checks to ensure satisfactory data communications with all end points, and technicians review vendor test results.

NOTE 5: Inoperative lines due to cable cuts are not an out-of-tolerance condition as defined in chapter 3. Restoration requires only performance verification; for example, contact with customer premise equipment at the distant end.

SECTION 2. OTHER MAINTENANCE TASKS

421.-499. RESERVED.

CHAPTER 5. MAINTENANCE PROCEDURES

500. GENERAL. This chapter establishes the procedures for accomplishing the various essential maintenance activities required for analog lines, on either a periodic or incidental basis. The chapter is divided into three sections. Section 1 describes the procedures to be used in making the performance checks listed in chapter 4, section 1. In section 2 are special maintenance procedures such as trouble shooting composite lines. Refer to Order 6000.15, General Maintenance Handbook for Airway Facilities, for additional general guidance.

501. BASIC MAINTENANCE PROCEDURE. The goal of this chapter is to identify procedures that will ensure timely testing while fully satisfying acceptance, safety, and other operational requirements.

a. With widespread application of network and line monitoring by centralized network management centers, it is not necessary to perform routine maintenance evaluations on lines that are under constant and real-time monitoring. Thus, for analog lines having real-time monitoring and for which the FAA has immediate and continuing access to the monitoring data, there is no periodic maintenance required by this handbook. For example, LINCS VG-6 and VG-8 lines have continuous real-time monitoring, with the FAA having constant and continuous access to the monitoring data.

b. Local FAA authorities may accept new leased lines from the vendor without requiring FAA qualified personnel to conduct separate line runs if **ALL** the following conditions are met:

(1) The vendor's tests are witnessed by qualified personnel who are able to judge satisfactory results. (Qualification of FAA or FAA contract personnel to witness testing may be determined by the Airways Facilities SMO Manager.)

(2) The vendor provides a copy of their test data demonstrating satisfactory test results (meets or exceeds established line parameters).

(3) The line is under real-time monitoring before and after being placed in operational status.

(4) For voice multipoint lines, the user performs functional checks of voice and signaling to ensure satisfactory operation with end points, and technicians review vendor test results which confirm line parameters to be within acceptable tolerances. For data multipoints, the user performs functional checks to ensure satisfactory data communications with all end points and technicians review vendor test results.

c. Parameters listed in chapter 3 generally have one value (the most stringent level) listed under *Standard* and another less stringent value under *Initial Tolerance*. The *Operating Tolerance* value is either "same as standard" or "same as initial". Whenever a line is tested, the FAA technician will accept the line as being within tolerances if the tested parameter value meets or exceeds the initial tolerance level. If line parameters can be adjusted, the FAA technician will work to bring the value as close as possible to the standard value.

d. The following cautions on input power should be followed when testing analog lines.

(1) The power level limit for FAA analog lines is -13 dBm, 3-second average. Power levels exceeding -13 dBm could cause noise in adjacent channels.

(2) For RCL and LDRCL vf lines referred to the 0 TLP, the maximum is -13 dBm, 3-second average.

e. For acceptance and commissioning, composite lines will be tested first segment-by-segment to establish a baseline useful in later fault isolation or troubleshooting. If the segment-by-segment testing is satisfactory, end-to-end testing should then be accomplished.

f. Vendors have the option to include a loopback device on the vendor side of the demarc to sectionalize and facilitate restoration of leased lines. Although these devices are normally set to operate with a 2713-Hz tone, some FAA applications require that a tone of 2413 Hz be used. Care must be taken to ensure that FAA testing does not inadvertently activate these devices which will result in the loss of the line until the devices can be deactivated. The 2713-Hz loopback tone is perilously close to the 2805-Hz guard tone used by many early versions of FAA VFSS equipment used to control RCAG channels. The 2413-Hz alternative is perilously close to the 2450-Hz key tone used for BUEC equipment. As a result, during the implementation of LINCS some regions have negotiated with local exchange companies to provide 1913-Hz tone to activated loopback control devices installed on radio control circuits.

502. FAA FORM 6000-14, PERFORMANCE RECORD - ANALOG LINES. Order 6000.15 contains guidance and detailed instructions for field utilization of FAA Form 6000 series *Technical Performance Record* forms. Entries shall be made in accordance with the instructions in Order 6000.15, except as indicated in the subparagraphs that follow. Figure 5-1 is a sample FAA Form 6000-14 which shows typical entries for an analog line.

a. Computer-Generated Test Results. Hardcopy printouts of computer generated test results may be used for site records in lieu of FAA Form 6000-14. Such hardcopy results may be generated either by the contractor with FAA technicians witnessing, or by FAA personnel using the automated line test equipment (ALTE).

b. Instructions on use of Form 6000-14.

(1) FAA Form 6000-14 is the single generic form which may be used for recording and filing maintenance actions on all types of analog lines. The form is designed so that local reproduction will allow blank forms to be made up in advance for all lines of a particular category by entering common information such as line type, sending facility, and relevant parameters.

(2) Form 6000-14 is designed so that all the relevant information on standards and tolerances may be listed on the front of the form with room for the optional frequency plot on the back. This form may be used for recording maintenance information on all FAA analog lines. Since this form is for use on all line types listed in chapter 3, some blocks on the form will not apply to some lines. Only fill in the blocks relevant to the line being tested.

(3) Elements of the form should be completed as follows:

(a) Circuit Identifier. Enter circuit identifier assigned; where available the communications service authorization (CSA) should be used. When there is no CSA, use an appropriate circuit identifier such as the circuit number.

(b) Acceptance Date. Enter the date that the line was originally accepted.

(c) Testing Date. Enter the date that testing is being conducted.

(d) Sending Facility/Receiving Facility. Enter appropriate facility names to indicate the direction in which line testing was conducted. Identify any responders installed.

(e) Configuration. Appropriate block is checked to indicate that the line was tested in either end-to-end or looped mode.

(f) Line Test Set-up (1004 Hz). At the sending end, enter the TLP level of the point at which the test set was connected to the line and the actual test tone level used to transmit the 1004-Hz tone. In most cases, the test set should be connected to a 0 TLP point and the sending level should be -13 dBm. Make the same entries for the receiving end.

(g) Line Type. Enter the line type based on the transmission media, not usage. Examples: LINCS VG-6, RCL via analog mux, and composite. For composite lines, list the individual line types that make up the line in the notes section of the form.

(h) Usage. Check voice or data as appropriate.

(i) Receive Level and Envelope Delay. This table allows receive level and envelope delay to be recorded for up to 33 different frequencies. In the second column, enter actual received level in dBm. In the third column, enter absolute envelope delay (the reading provided by the test set) in microseconds (μsec). When recording results of a three-tone slope test, enter the test results in the blocks for the 404-, 1004-, and 2804-Hz frequencies.

FIGURE 5-1. SAMPLE OF FAA FORM 6000-14 WITH ENTRIES

PERFORMANCE RECORD - ANALOG LINES

CIRCUIT IDENTIFIER	ACCEPTANCE DATE	TESTING DATE
MCIL D XXXXX	9/18/95	9/18/95

Sending Facility	Receiving Facility	CONFIGURATION
ZAB	QXP	End-to-End [ ] Looped [X]

Line Test Set-up (1004 Hz) Send Point	Receive Point	LINE TYPE	USAGE
0 TLP -13 dBm	0 TLP -13 dBm	VG8	VOICE [ ] DATA [X]

RECEIVE LEVEL AND ENVELOPE DELAY DISTORTION

FREQ (Hz)	LEVEL (dBm)	DELAY (μsec)	FREQ (Hz)	LEVEL (dBm)	DELAY (μsec)	FREQ (Hz)	LEVEL (dBm)	DELAY (μsec)	FREQ (Hz)	LEVEL (dBm)	DELAY (μsec)
304	-14.9	—	1004	-13.5	95	1704	-13.1	74	2404	-13	524
404	-14.4	2286	1104	-13.5	55	1804	-13	129	2504	-13.1	610
504	-14	1276	1204	-13.4	26	1904	-12.9	162	2604	-13.2	755
604	-13.8	763	1304	-13.4	21	2004	-13	220	2704	—	—
704	-13.7	494	1404	-13.3	0	2104	-12.8	264	2804	-13.3	1103
804	-13.6	294	1504	-13.2	44	2204	-12.9	356	2904	-13.1	1366
904	-13.6	174	1604	-13.1	55	2304	-13	420	3004	-12.9	1730

PERFORMANCE WORKSHEET

Parameters		Initial Value	Present Value	Standard	Initial Tolerance
1. 1004 Hz net loss		0.5 dB	0.5 dB	Ø dB	±3 dB
2. Attenuation Distortion	304 To 3004 Hz	- 0.7 + 1.4 dB	- 0.7 + 1.4 dB	- + dB	- 2 + 10 dB
	404 To 2804 Hz	- 0.7 + 0.9 dB	- 0.7 + 0.9 dB	- + dB	- 2 + 4 dB
	___ To ___ Hz	- + dB	- + dB	- + dB	- + dB
	___ To ___ Hz	- + dB	- + dB	- + dB	- + dB
3. Envelope Delay Distortion[1]	804 To 2604 Hz	755 (μsec)	755 (μsec)	≤ 1300 (μsec)	≤ 1400 (μsec)
	___ To ___ Hz	(μsec)	(μsec)	(μsec)	(μsec)
	___ To ___ Hz	(μsec)	(μsec)	(μsec)	(μsec)
	___ To ___ Hz	(μsec)	(μsec)	(μsec)	(μsec)
4. Signal-to C-Notch Noise Ratio		30 dB	30 dB	31 dB	≥29 dB
5. Intermodulation-Distortion[1]	2nd Order	46 dB	46 dB	43 dB	>42 dB
	3rd Order	51 dB	51 dB	46 dB	>45 dB
6. Phase Jitter[1]	4 to 300 Hz	3 deg	3 deg	16 deg	<18 deg
	20 to 300 Hz	<3 deg	<3 deg	6 deg	<8 deg
7. Impulse Noise[1]	Counts	Ø	Ø	<30	<30
	Minutes	15	15		
	Threshold 65 dBRNC0				
8. Peak to Average Ratio (P/AR)		81	81	81	±4

Comments/Notes:

TOLERANCES DOUBLED FOR LOOPED-LINE TESTS.

[1] Parameter applies only to lines used exclusively in data applications.

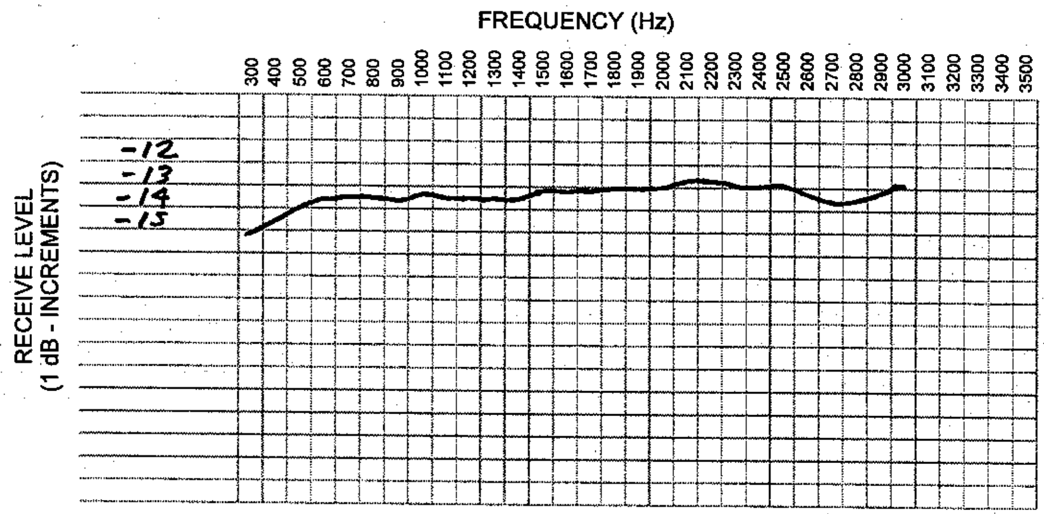
Date 9/18/95 Signature Harry McAnglerion

FAA Form 6000-14 (10/95) LOCAL REPRODUCTION AUTHORIZED NSN: 0052-00-916-2000

FIGURE 5-1. SAMPLE OF FAA FORM 6000-14 WITH ENTRIES (Continued)

LINE TYPE VG 8	CIRCUIT IDENTIFIER MCIL D XXXXX	ACCEPTANCE DATE 9/18/95	TESTING DATE 9/18/95
Sending Facility ZAB	Receiving Facility QXP		CONFIGURATION End-to-End ☐ Looped ☒

PLOT AND FREQUENCY LEVEL



NOTES:

FAA Form 6000-14 (10/95) (Side 2) LOCAL REPRODUCTION AUTHORIZED

(j) Performance Worksheet Header. The *Initial Value* column is obtained at the time of line acceptance. *Present Value* is the column in which parameter readings from current testing will be entered. The remaining two columns are provided for inserting the standard and initial tolerance limits for the particular type of line as listed in the blue pages of chapter 3.

(k) 1004-Hz Net Loss. Enter the net loss for a 1004-Hz tone. This value is computed from test tone levels recorded under *Line Test Set-up*, and is computed by subtracting the *Receive Point* level in dBm from the *Send Point* level in dBm. A positive value (positive loss) indicates that the received level is smaller than the send level. (ALTE can make this normalization of readings to 1004 Hz and provide the results as output.)

(l) Attenuation Distortion. Enter the attenuation distortion for each of the frequency bands specified in the standards and tolerances for the line type. Enter the appropriate frequency bands from the standards and tolerances in the spaces provided. For each frequency band, note the maximum and minimum test tone levels received for all frequencies within this band. The difference, in dB, between the highest test tone level received and the 1004-Hz received level is recorded as negative attenuation distortion; the difference, in dB, between the lowest test tone level received and the 1004-Hz received level is recorded as positive attenuation distortion. As an example, assume a 1004-Hz received level is -13 dBm. The highest received level was a 2004-Hz tone of -12 dBm, and the lowest received level was a 3004-Hz tone of -16 dBm. This gives an attenuation distortion of +3/-1 dB.

(m) Envelope Delay Distortion. For lines used exclusively in data applications, enter the envelope delay distortion for each of the frequency bands specified in the standards and tolerances for the line type. Enter the appropriate frequency bands from the standards and tolerances in the spaces provided. For each frequency band, note the maximum and minimum envelope delay times recorded for all frequencies within the band. The difference, in µsec, between the longest and shortest delay times recorded, is the envelope delay distortion for that frequency band.

(n) C-Notched Noise. Enter the C-notched noise level, measured in dBRNC, on the first line. On the second line, enter the level corrected to the 0 TLP in dBRNC0. In most cases, the noise will be measured at a 0 TLP, so these two levels will be the same number.

(o) Signal-to-C-Notched Noise Ratio. Some test sets will display this reading automatically. If so, this reading may be entered directly. If not, Signal-to-C-notched noise ratio is computed by adding 90 dB to the 1004-Hz received level recorded in *Line Test Set-up* and then subtracting the recorded C-notched noise level from this value. As an example, assume the 1004-Hz received level is -13 dBm and C-notched noise measured is 42 dBRNC. Signal to C-notched noise is then:

$$(-13 + 90) - 42 = +77 - 42 = 35 \text{ dB}$$

(p) Intermodulation Distortion (IMD). Enter second and third order IMD as provided by the test set.

(q) Phase Jitter. Enter phase jitter measured for the appropriate bandwidth(s).

(r) Impulse Noise. Enter the total number of impulses counted, the number of minutes elapsed (normally 15) during which impulses were counted, and the threshold setting corrected to the 0 TLP in dBRNC0 in block 9 on the form.

(s) Peak to Average Ratio (P/AR). Enter the P/AR value from the test.

(t) Comments/Notes. This space may be used to record relevant information such as exact types of segments that make up a composite line or other data that is not specified elsewhere on the form. If this form refers to a LINCS line for which there is a trouble ticket opened, the trouble ticket number should be entered here. (The format for LINCS trouble ticket numbers is MMDDTTTT.) There could also be recent history on this line and other information of use to the technician.

(u) Date and Signature. Enter the date that the form was completed and the signature of the person completing the tests.

(v) Back of Form. All information on the back of the form is optional and may be used as directed by local procedures.

1 **Header Information.** Details of the line and dates to identify the source of information relevant to the optional details recorded on the back of the form.

2 **Plot of Frequency and Receive Level.** Optional plot of frequency and receive levels if required or desired by local procedures.

3 **Notes.** May be used for any expansion or explanatory information relevant to the optional plot.

503. TEST EQUIPMENT REQUIRED.

a. There are many types of communications test sets in use at FAA field facilities. Automated Line Test Equipment (ALTE) consisting of the Hekimian REACT 2000 and Ameritech AM-3 responders are used extensively throughout the FAA. The ALTE is described in following subparagraphs. Stand-alone test sets are also found in many FAA facilities. Characteristics and capabilities of many of these test sets are shown in table 5-1. This information is provided as guidance in determining if a particular piece of test equipment is suitable for use in verifying line performance parameters. For example, from the table we know that a TTS-44 will not measure all parameters required for a line used in data applications.

b. Description of the Automated Line Test Equipment (ALTE). The ALTE or Hekimian REACT 2000, provided at ARTCC facilities, is a fully automated test operations support system that includes both

TABLE 5-1. TEST EQUIPMENT CHARACTERISTICS

	1004 Hz Loss	Attenuation Dist.	Idle Chan Noise	C-Weighted Noise	Noise w/ Tone	S/N (Direct)	P/AR	Impulse Noise	Env. Delay Dist.	Phase Jitter	Intermod Dist.	Remote Control	Printer Output	Graphic Display	Signalling	Digital Testing	Signal Generator	PCM Access
Ameritec AM8A	X	X	X	X								X	X		X		X	X
Berry 9000	X	X	X	X	X			O	O						X		X	O
CXR Telcom 5200	X	X	X	X	X	X	X	X	O	O	O	O	X	X	O	O	X	O
Halcyon 701A	X	X	X	X	X		O								O		X	
Hekimian 3701	X	X	X	X	X	X	O	O	O	O	O	O			O		X	
Hekimian 3903	X	X	X	X	X		O	O	O	O	O	O	X	O			X	O
Hewlett Packard 4934	X	X	X	X	X	X	X	X									X	
Hewlett Packard 4935	X	X	X	X	X	X	O	X									X	
Hewlett Packard 4945	X	X	X	X	X	X	X	X	X	X	X	X	X				X	
Northeast Elec. TTS-37	X	X	X	X														
Northeast Elec. TTS-44	X	X	X	X	X												X	
Sage 930A	X	X	X	X	X	X	O	O	O	O	O	O	O		X	O	X	O

X = Primary Capability O = Optional

hardware and software (on a DEC MicroVAX computer workstation) that allows both interactive and automated testing. Figure 5-2 shows the basic design of the ALTE. The Hekimian REACT 2000 is a very stable system that has been ISO 9001 certified by both Bellcore and AT&T. (The ISO 9001 certification indicates that systems satisfy highest standards of quality control in design, development, production, installation, and service.) Analog line test resources enable testing voice-frequency (voice or data) lines at metallic points in the network. An analog line test node of the ALTE/Hekimian REACT 2000 includes two types of equipment: line access (switching) equipment (Hekimian 3200 metallic test access unit), and line test equipment (Hekimian 3701 or 3703 communications test systems). The identification of Hekimian manuals and basic operating characteristics of the ALTE hardware items are shown in table 5-2.

FIGURE 5-2. TYPICAL REACT 2000/ALTE DEPLOYMENT

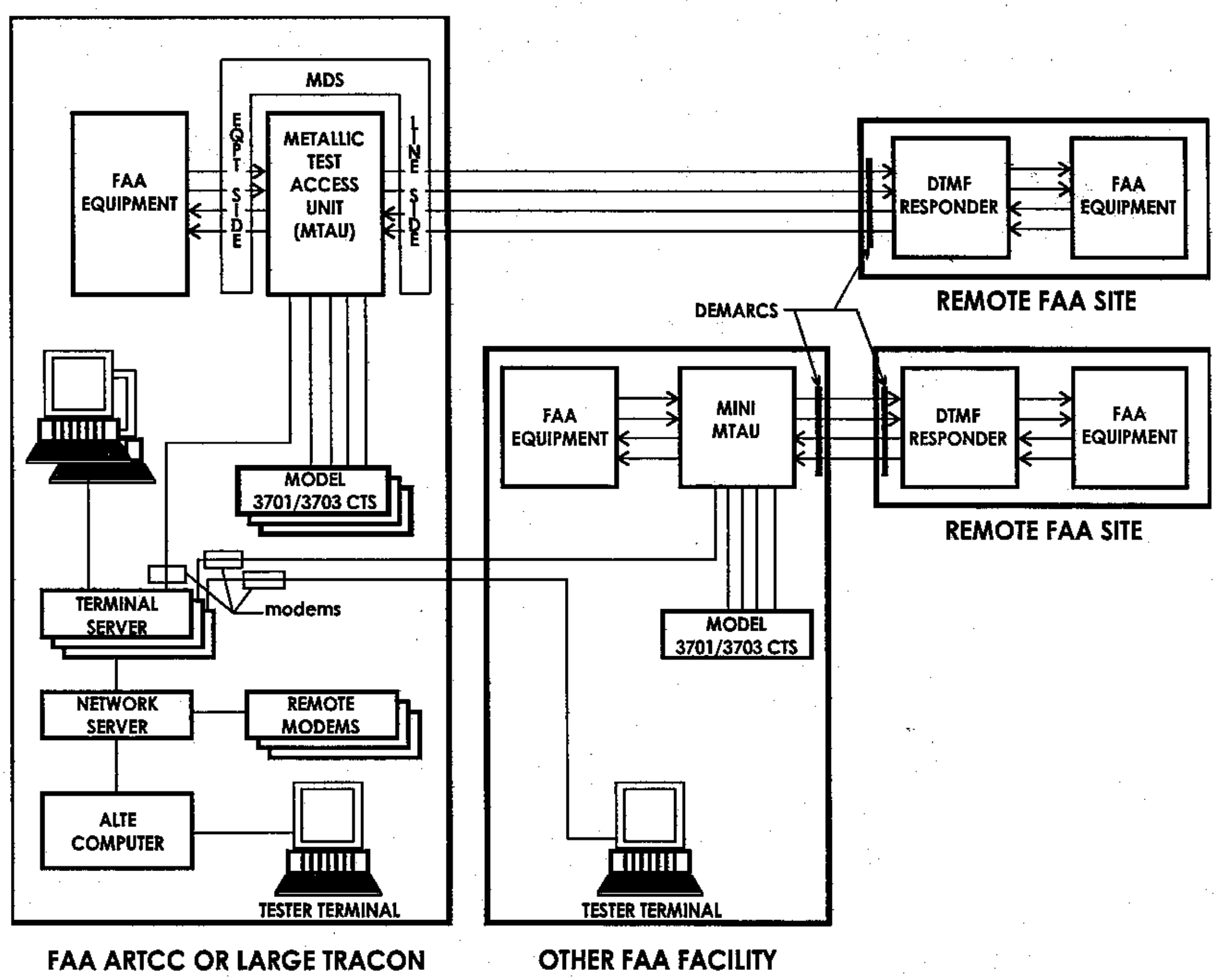


TABLE 5-2. ALTE DESCRIPTION

Model Number	*Manual Number*	*Description*
3200	HKMN 660-750-020	Metallic Test Access Unit (MTAU) provides a switched access for voice-frequency facility testing.
3703	HKMN 103-370-500	Performs 40-Hz to 20-kHz level, noise, frequency, and return loss measurements. Also includes capabilities for programmable TLP, noise mode, c-notch and c-message filters, frequency counter with 1-Hz resolution, IMD, P/AR, phase jitter, envelope delay, hits, and use of responders.
3701	HKMN 103-370-500	Same basic capabilities as the 3703 except that the front panel controls allow test personnel to work directly from the 3701 location rather than at the ALTE keyboard.

(1) **Central Unit.** The central unit of the ALTE is the MicroVAX computer; with it are terminal servers which allow several terminals to be networked to the computer. Remote terminals, either directly connected or using modems, allow users at various locations to access and use the system. The Hekimian 3200 MTAU, located with the ALTE computer, contains relays controlled by the computer. These relays allow access to circuits connected through the MTAU. Each ALTE equipped facility has one or more Hekimian 3700 series test sets which receive commands from the ALTE computer. By selecting from various menus at a remote terminal, the operator can command access and testing of circuits connected through the MTAU. The ALTE systems operator controls access to the ALTE computer with the use of passwords and lists of authorized user ID's.

(2) **Metallic Test Access Unit.** The basic MTAU configuration includes an access control shelf and line relay shelf that provides switched access for voice-frequency facility testing. It removes the need for test board jack fields, which increases test personnel productivity by permitting remote line access and testing. The operating characteristics of the MTAU support the following user requirements:

- Bridge and split access switching
- Two-wire, 4W, 6W, and 8W line capability
- RS-232 test position control
- Local and remote (unattended) control
- Transmission, signal, and cable testing
- Built-in system diagnostics

(3) **Communications Test Systems.** The ALTE communications test systems (CTS) are the Hekimian models 3701 and 3703. While each CTS has slightly different characteristics and capabilities, they generally provide test personnel the resources to perform analog line tests for the parameters identified in chapter 3 of this order.

(4) **User Manuals.** Refer to the appropriate section of ALTE/Hekimian REACT 2000 user manuals for detailed guidance on conducting required analog line tests. In referring to the appropriate Hekimian manuals, make sure that the manuals used are the latest issue number relevant to the installed software release.

(5) **ALTE Macros, Databases, and Printouts.**

(a) **Macros.** The ALTE Systems Administrator can develop and use macro programs to perform any available testing. When properly executed, such macros can save time and effort required to perform complex and/or repetitive testing.

(b) **Database.** Testing results may be stored in the MicroVAX database of ALTE. At the conclusion of testing a line when the technician is backing out of the testing menus, ALTE screens prompt him to save the test results as *benchmark* or *last* results. For acceptance tests such results would be the baseline (or if the line has been reaccepted after major reengineering - not just reaccepted after maintenance for an out-of-tolerance condition). The ALTE database will allow saving of up to 10 *last* test results so that the history of a particular line can be reviewed and analyzed by authorized technicians.

(c) Printouts. When the testing results are saved, the technician is also prompted as to whether the results are to be printed and on what printer. Such printouts may be used as the hard copy file or used to assist in filling out form 6000-14.

(7) Passwords and User ID's. The ALTE systems administrator normally assigns and controls access to passwords required by the ALTE processor to permit sign-on by users from throughout the facility as well as remote users. Different passwords may be used to enable ALTE access for different types of functions and thus allow users access only to required elements of ALTE that are needed for them to complete their personal tasks. User identification can be handled by assignment of some known user ID such as the maintenance management system (MMS) ID.

(8) Description of the Ameritec AM3 Responder. At the remote end of lines connected to the ALTE or where segments of composite lines interface, the FAA usually installs a responder. In most cases this will be an Ameritec model AM3 responder. This four-wire responder can be commanded by dual-tone multifrequency (DTMF) tones sent on the line under test. Similar types of responders may also be used, provided they can be commanded by the ALTE. The model AM3 and ALTE combination allows the following functions to be tested.

(a) For line runs, select the ALTE menu for *Loop Test Routines* and conduct the *level and noise* test to get looped net loss at 1004 Hz and also the signal-to-C-notched noise ratio. The looped P/AR test should be run to determine if it is within operational limits. If the P/AR test here appears to be outside acceptable limits, move on to procedures to conduct a complete line run to isolate the cause.

(b) Should a line tested in looped mode be out of tolerance, proceed to the ALTE menu for *Single Ended Ameritec Tests*. Here again, the P/AR test may be conducted first to determine which segment of the line is out of operational tolerance. Then run the single-end tests for appropriate test parameters to help isolate which parameters are out of tolerance.

504. GENERAL MEASURING TECHNIQUES.

a. Overall Loss and Frequency Response. To determine the overall loss and frequency response characteristics of an analog line, fixed level audio frequency tones in the voice frequency range (300 to 3000 Hz) are applied to the sending end of the line to be tested. Depending on the particular test being conducted, these tones may be either at every 100 Hz (to develop the baseline for lines being commissioned) or with a three-tone slope with frequencies at 404, 1004, and 2804 Hz. Measure and record the level of these tones at the receiving end of the tested line with appropriate testing equipment. Refer the recorded levels to a reference level established at 1004 Hz and (optionally) transcribe these values to the plot on FAA Form 6000-14 to depict the overall loss and frequency response characteristics of the line.

b. Discrepancies. Testing measurements can be made for a segment of the line or for the line from end-to-end. Measurements normally start at the reference frequency of 1004 Hz where a check is made against the standard listed in chapter 3. If performance discrepancies are discovered at this point, no further testing should be conducted until the fault causing the discrepancy is isolated and corrected; until then, any further measurements likely will be erroneous.

c. Looped parameters. Circumstances sometimes require that a line be tested with the distant end looped back (using a responder or remotely controlled test equipment).

(1) A loopback test is an effective way of locating faults and impairments. By looping and testing lines at progressively further points, the element causing the complaint will be identified.

(2) Since the parameters of chapter 3 are for end-to-end testing, an adjustment is required to evaluate a looped line. To convert end-to-end parameter values to looped parameters, double the tolerance listed for net loss, attenuation distortion, phase jitter, envelope delay distortion, and impulse noise for the type of line being tested. The tolerances for signal-to-C-notch noise ratio and intermodulation distortion are logarithmically doubled for looped measurements. That is, they are degraded by 3 dB. The P/AR parameter will remain as ±4 units from commissioned value for both end-to-end and looped tests.

d. Measuring Techniques. The accuracy of voltage and decibel measurements is often as dependent on measuring techniques as it is on the quality of testing instruments used. Factors that affect techniques are: purpose of the measurement, line impedance, line balance, and the nature of the measured signal. Generally, measurements are made to test the performance of a line in service, to locate trouble, or to align a line to meet specifications. In-service and troubleshooting measurements are usually made on a bridging basis. System alignment often involves power level measurements using a resistive load equal to the characteristic impedance of the line.

e. Bridging and Terminated Measurements. Of these two methods of inserting the test equipment into the line to be tested, the preferred method is to use terminated measurements.

CAUTION: Always be aware that test tones used in line maintenance are potentially interfering and disorienting (in other words, they may have negative effects on human and equipment performance). If test tones have not been properly blocked out from the equipment sides of a line under test, they may cause major irritation and disorientation to personnel still on the line. Follow specific procedures detailed in chapter 5 for when and where to apply test tones. Also, keeping tones at or below maximum levels will help in avoiding annoyance to personnel or causing interference in adjacent carrier channels.

(1) Bridging. Bridging measurements are usually made where disabling the line is inconvenient, where the line impedance is known to be a definite fixed value, or where only voltage is to be measured. In bridging measurements, the test equipment meter is connected directly across a functioning line; e.g., a meter is connected across the terminals of a telephone loop and telephone set to measure power level on a bridging basis. The accuracy of this measurement in dBm depends upon how close the impedance characteristic of the loop and telephone set is to 600 Ω.

(2) Terminated. In terminated measurements, a fixed impedance replaces the load provided by the terminating equipment that is normally connected to the line. The impedance may be internal or external to the meter. Most transmission test sets have built-in impedance. The advantage of terminated measurements is that the impedance of the load is known and fixed, which results in more valid measurements.

f. Line Impedance. When making voltage or power level measurements, particular attention must be paid to line impedance. If the impedance at the point of measurement is 600 Ω resistive, most test sets will read power levels directly in dBm. Should the line impedance be a known value other than 600 Ω, dBm can be obtained by use of the formula:

$$\text{dBm} = 10 \log_{10} E^2/0.001R$$

where R is the line impedance in ohms and E is the voltage rms (root mean square) across the impedance.

g. Termination Balance. A potential source of error in measurement is the use of an unbalanced meter to measure voltage or power levels in a balanced line. If an attempt is made to bridge or terminate balanced lines with a meter that has unbalanced input terminals (one terminal connected directly to the meter chassis), stray, common-mode voltage on the wiring of the line might cause erroneous readings. Also, crosstalk between the line under test and other lines may be increased while the test set is connected.

h. Signal Level and Noise. Another source of error in voltage or power measurements is the presence of noise. When measuring small voltages or low power levels, noise voltages in the line may make the meter reading too high. When reading test tone voltages of less than 0.01 volt or less than -20 dBm, line voltage should be measured without the test tone to determine the amount of noise. If the noise is more than 12 dB below the test tone, it should not appreciably affect the accuracy of the measurement.

i. Composite Signal Level of Several Tones. When several tones are combined in a common load impedance, the level of the composite signal is NOT the sum of the individual signal tone levels in dBm. To obtain the total, or composite, level of several signal tones applied simultaneously to a common line, each individual level must be converted to an absolute power in watts; the individual power levels are then added and the total converted to dBm.

EXAMPLE: Find the composite level of eight tones, each at a level of +2 dBm and each of a different frequency in the voice frequency band. The formula for converting dBm levels to power is:

$$\text{dBm} = 10 \log \frac{P_2}{P_1}$$

The calculation is:

$$2.0 = 10 \log \frac{P_2}{1\text{ mW}};\ \text{Antilog} \frac{2}{10} = \frac{P_2}{1\text{mW}}$$

The power level for each tone is:

$$P_2 = 1.582(1\text{ mW}) = 1.582\text{ mW}$$

Adding power levels:

1.582 + 1.582 + 1.582 + 1.582 + 1.582 + 1.582 + 1.582 + 1.582 = 12.7 mW

Converting back to dBm level:

$$\text{dBm} = 10 \log \frac{12.7\text{ mW}}{1\text{ mW}} = 10\ (1.103) = \mathbf{11\ dBm}$$

NOTE: The above formula is adaptable to all calculations and is not restricted to situations with equal tones.

505.-509. RESERVED.

SECTION 1. PERFORMANCE CHECK PROCEDURES

510. MONITOR CHECK PROCEDURE FOR THE LEASED INTERFACILITY NAS COMMUNICATIONS SYSTEM (LINCS) NEWBRIDGE 4602 SYSTEM STATUS DISPLAY (SSD).

a. Object. This procedure checks the Newbridge 4602 SSD to view the condition of the LINCS network and of selected LINCS lines.

b. Discussion. The SSD is a valuable tool for monitoring the health of the local LINCS network. The display screen shows icons that represent both facility-level and interface-card level elements of the network. Lines that connect the icons represent the digital communications paths between facilities. A change in color of an icon or line represents a change in performance or status of that element. The printer provides a hard copy of network information for later review. When degradation of a network element has been detected, and the technician is certain that the problem is not FAA related, the LINCS help desk should be contacted. The LINCS help desk uses the Newbridge 4602 Network Management System (NMS) that has the same status display as the SSD. The NMS logically has more powerful software (and additional hardware) to enable the help desk to accomplish detailed network performance tasks. For more detailed information refer to the LINCS operational handbook.

c. Test Equipment Required. Newbridge 4602 system status display system.

d. Conditions. This procedure requires that the technician be familiar with operation of the 4602 SSD and has received training on this system. Instructions which refer to clicking the mouse button are referring to the left mouse button unless otherwise stated.

e. Detailed Procedure.

(1) 4602 SSD Set-Up.

(a) Verify that all components of the 4602 SSD are powered on. Verify also that the printer is on and configured for use with the SSD.

(b) If it has not already been done, log in to the SSD by entering the appropriate password. Upon successful login, the network map window will appear.

(2) Checking the SSD.

(a) View the SSD screen. If a red triangular sign with an exclamation mark in it is shown, click once on it. The red triangle with the exclamation mark is the trouble ticket icon. This icon indicates that a new network trouble ticket has been received.

(b) The screen will show in red the network map element that generated the new trouble ticket. Double click on the red network element to display the device-level view.

(c) If the red trouble ticket icon is not shown but there are red network elements, double clicking on the red network elements will display the device-level view of those elements.

(d) If neither the trouble ticket icon nor any red network elements are shown in the network view, it may be necessary to refresh the SSD. Refreshing the display is accomplished by selecting any network element and clicking on it once. Next, press and hold the right mouse button and a menu will appear. From that menu select HIGHLIGHT and while still holding the right mouse button, move the pointer on the screen to the right until a second menu appears. Position the pointer to select SHOW TROUBLE TICKET from the second menu and then release the mouse button.

(e) Double click on the red device-level element in the network view screen. A detail window will appear on the right side of the screen. This window shows a card-level view of the problem device.

(f) Single click on the red card-level device to select it.

(g) Press and hold the right mouse button; a menu will appear. Select LIST from the menu, and, while still holding the right mouse button, move the screen pointer to the right until a second menu appears. Position the pointer to select TROUBLE TICKET from the second menu and release the right mouse button.

(h) A trouble ticket window will appear below the device window. Click once on MAKE LIST from the window to list the trouble tickets and their status.

(i) Double click on a trouble ticket to open it. Once opened, the trouble ticket can be viewed for status or printed.

(j) Closing the trouble ticket window acknowledges the trouble ticket. Close all device-level views and return to the network view. Click on the MAP IS SHOWING OBJECTS WITH OPEN TROUBLE TICKETS box in the network view. All elements in the network will be shown in green. Refresh the display as described in step (d) above.

(k) If an open trouble ticket is encountered, contact the LINCS MCI technician or the network management center help desk.

511. GENERAL PROCEDURE WHEN USING THE ALTE. The following information should be used in conjunction with procedures in succeeding paragraphs whenever the ALTE is used to test lines:

a. The ALTE may be used by personnel within a facility so equipped by physically working with components of the system such as at the computer console (usually near the main demarc) or by using one of the communications test sets (CTS) that may be available elsewhere throughout the facility.

b. The ALTE can be used by anyone with a PC, a modem, and proper passwords and communications software. With prior arrangement, personnel from other FAA facilities with at least an MTAU may arrange with the ALTE systems administrator in a facility to use the local ALTE remotely by obtaining passwords, User IDs, and procedures that allow them to call assigned modems which place them in communications with the ALTE network controller and thus into the metallic test access unit (MTAU). The major advantage of arranging remote access to the ALTE is that the personnel from the distant facility can then call into the remote facility to test/maintain lines they have running through that facility without needing anyone from the remote facility to meet them on the line(s) under test. Advanced arrangements are required for this remote access so that passwords and user ID's can be assigned/made known and restricted circuit access can be programmed into the ALTE.

c. Determine if the tests will be conducted using macros previously programmed into the ALTE database or using tests determined individually by the current operator.

(1) To use ALTE macros, enter the name of the selected macro when so prompted by the ALTE menu screens. See appendix 2 for details of developing and using ALTE acceptance masks and the appropriate Hekimian REACT 2000 manuals for details on developing and using macros.

(2) Procedures for individually selected tests are outlined below and further discussed in the appropriate Hekimian user manuals.

d. When tests are completed, release the line and print or store the test results. Test results at commissioning or recommissioning might be stored in the ALTE database as the benchmark against which later test results are compared. Subsequent test results can be stored in the database as LAST (up to 10 LAST results per line). Stored test results may later be recalled by any operator with a valid log-on. Test results may also be printed out on a printer specified by the transportation system specialist (the selected printer can be at the ALTE or a remote printer at the operator's location).

e. Review the test results to determine if the line satisfies all key parameters listed in chapter 3. If parameters are satisfied, return the line to service and file/post the test results. If key parameters are unsatisfactory, submit a trouble ticket and take the line out of service.

f. Log off the ALTE.

512. ANNUAL LINE RUN USING ALTE.

a. Object. This procedure provides for checking the basic parameters of line performance (gain, attenuation distortion, and signal-to-noise) on an annual basis using the ALTE.

b. Discussion.

(1) Annual line runs are performed on all lines, including standby (or redundant) lines, with the exception of lines described in paragraph 401.

(2) Chapter 3 lists the specific performance parameters, tolerances, and limits applicable to all classes of analog lines used within the FAA.

(3) Annual line runs on composite lines should be performed on an end-to-end basis, with results compared to the composite line parameters listed in paragraph 309. If the results indicate the composite line is not within tolerances, the line should be taken out of service for maintenance. Segment-by-segment tests should then be performed to determine which is defective and corrective action should be taken on the defective segment.

(4) FAA Form 6000-14 may be used to record maintenance action on all analog lines. Local authorities may also utilize computer printouts (from FAA ALTE or contractor-automated testing equipment) as the record for such maintenance or may have such printouts attached to a form 6000-14.

c. Test Equipment Required. Automated Line Test Equipment (ALTE). (This is the Hekimian REACT 2000.)

d. Conditions.

(1) Ensure that the line to be tested has been released from service by air traffic control personnel or other user and that the operating equipment at each end has been lifted from the line. Service may be maintained by either providing a satisfactory alternate route for operational data or during scheduled maintenance time when advanced coordination has arranged for the operational service to be unavailable to the user during specified times.

(2) The maximum FAA test tone power level applied at any frequency shall be -13 dBm at the 0 TLP.

> **NOTE:** This power level is used for measuring frequency attenuation, measuring net loss at 1004 Hz, and other line performance evaluations. Equipment lineup levels are specified in applicable equipment orders.

(3) Use part 3 of the ALTE/Hekimian REACT 2000 user manual with the version number that corresponds with the software release installed on the ALTE. The Hekimian user manual describes how to use the REACT System/ALTE to test analog lines, specifically describing the menus and menu selections as well as the procedures for performing each type of ALTE analog test.

(4) The ALTE menus assist users in efforts to access, configure, and test analog lines. Actions to be taken in the various menus are slightly different depending on whether circuits to be tested are contained in the ALTE database or not. See figure 5-3 for a view of typical ALTE/REACT analog testing flowchart and menus - actual menus may be slightly different than those shown as the software versions change and menus are updated. Working through the ALTE menus allows the user to identify the type of testing operation desired, then to select the testing resources to be used and the analog line to be tested, to conduct desired testing on that line, and lastly to get the results of such testing stored in the computer or printed on the screen or selected printer.

e. Detailed Procedure. Use in combination with the general procedure for ALTE of paragraph 511.

(1) 1004-Hz Loss. Perform the 1004 Hz net loss test in the looped mode. Evaluate the results in accordance with the tolerance listed in chapter 3 for that type of line, and if within tolerance (looped testing results are twice the deviation on measurements as shown in blue pages for single-ended test results), proceed with testing other parameters. If out of tolerance, do not proceed on to other parameters until the cause of the difficulty has been identified and corrected. This parameter must be within tolerance before additional parameters are tested.

(2) P/AR. Conduct a P/AR test and analyze the results. If this is within tolerance, (no more than ± 4 units from the commissioned value in the looped mode), the annual line run requirement is satisfactorily completed, and the test can be ended and results can be filed. If the P/AR result is not within tolerance, proceed to the attenuation distortion and signal-to-C-notched noise ratio tests described below in order to develop more detailed information on the line.

(3) Attenuation Distortion. If the P/AR test is out of tolerance, perform a three-tone slope test on the line and record the results. When prompted as to whether to normalize the results to the 1004-Hz net loss test, recommend replying *yes* so that the ALTE results printout/screen displays the values already adjusted for more or less loss relative to the 1004-Hz reference. Deviation of looped mode test results may be twice the values shown in chapter 3.

(d) Signal-to-C-notched noise ratio. If the P/AR test is out of tolerance, perform, analyze, and record the signal-to-C-notched noise ratio test as specified in the Hekimian manual. Looped mode measurements will be 3 dB less (or twice as bad) than parameters shown in chapter 3.

513. "AS REQUIRED" TESTING USING ALTE.

a. Object. This procedure provides for using the ALTE to perform testing required for initial acceptance of lines, for acceptance of composite lines, and for revalidating lines that were out-of-service for maintenance.

b. Discussion.

(1) Testing of lines is required when the line is initially accepted for service, or after completion of corrective action for a line that was out-of-tolerance. Vendor test data may be used to satisfy this requirement if testing was witnessed by qualified FAA or FAA contract personnel, a copy of test data is provided to the facility, and the line is under real-time monitoring.

(2) Chapter 3 lists the specific performance parameters, tolerances, and limits applicable to all classes of analog lines used within the FAA.

(3) FAA Form 6000-14 may be used to record maintenance action on all analog lines. Local authorities may also utilize computer printouts (from FAA ALTE or contractor-automated testing equipment) as the record for such maintenance or may have such printouts attached to a form 6000-14.

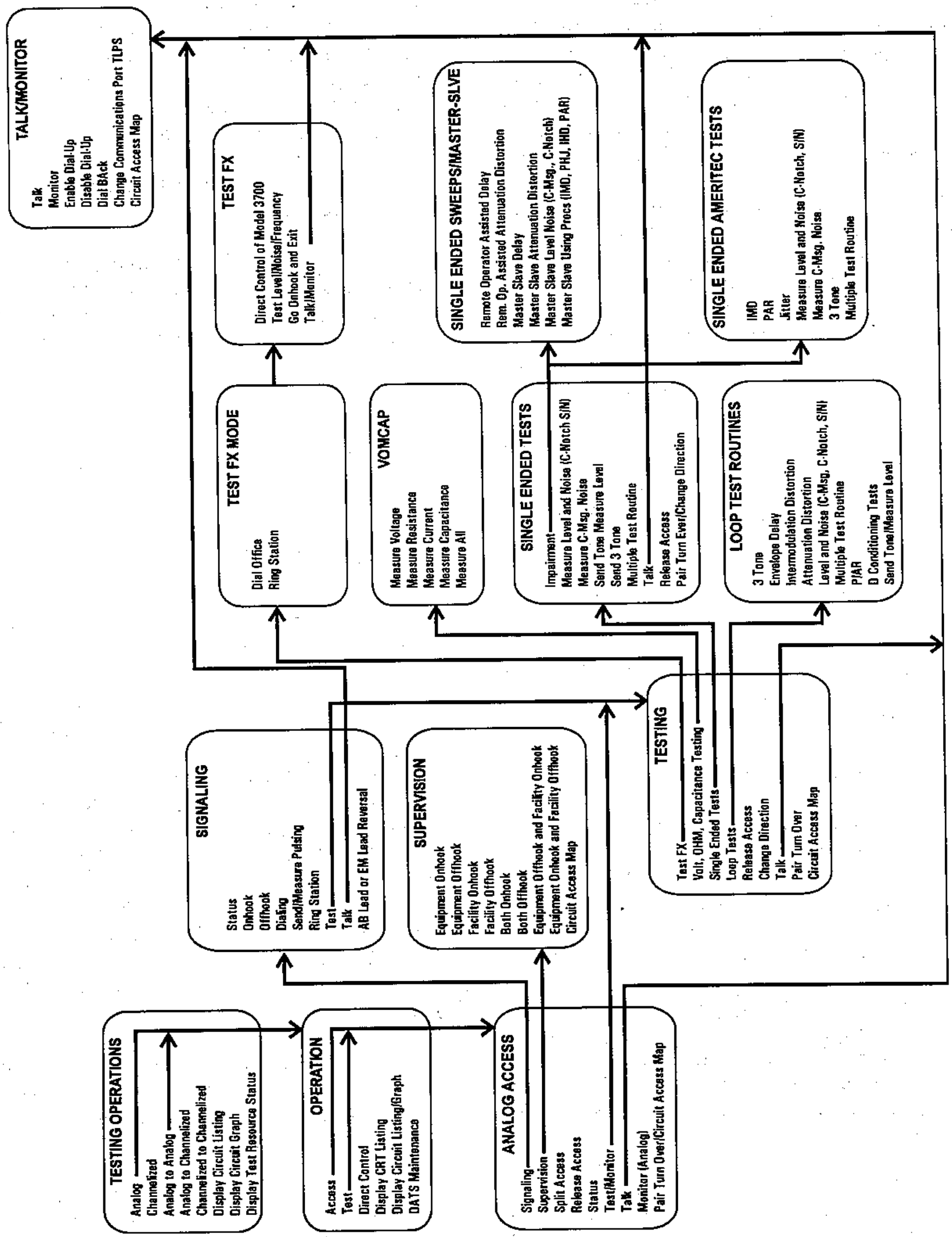
c. Test Equipment Required. Automated Line Test Equipment (ALTE) (Hekimian REACT 2000).

d. Conditions.

(1) The maximum FAA test tone power level applied at any frequency shall be -13 dBm at the 0 TLP.

NOTE: This power level is used for measuring frequency attenuation, measuring net loss at 1004 Hz, and other line performance evaluations. Equipment line-up levels are specified in applicable equipment orders.

FIGURE 5-3. TYPICAL REACT 2000/ALTE ANALOG TESTING FLOWCHART AND MENUS



(2) Use part 3 of the ALTE/Hekimian REACT 2000 user manual with the version number that corresponds with the software release installed on the ALTE. The Hekimian user manual describes how to use the REACT System/ALTE to test analog lines, specifically describing the menus and menu selections as well as the procedures for performing each type of ALTE analog test.

(3) The ALTE menus assist users in efforts to access, configure, and test analog lines. Actions to be taken in the various menus are slightly different depending on whether circuits to be tested are contained in the ALTE database or not. See figure 5-3 for a view of typical ALTE/REACT analog testing flowchart and menus - actual menus may be slightly different than those shown as the software versions change and menus are updated. Working through the ALTE menus allows the user to identify the type of testing operation desired, then to select the testing resources to be used and the analog line to be tested, to conduct desired testing on that line, and lastly to get the results of such testing stored in the computer or printed on the screen or selected printer.

e. Detailed Procedure. Use in combination with the general procedure for ALTE of paragraph 511.

(1) Line Acceptance. The procedure below is designed for the variety of ALTE users in the FAA. For specific and detailed procedures, refer to the Hekimian REACT 2000 user manuals specifically written for the software release installed on the ALTE.

(a) Establish communications with the ALTE/REACT system controller.

(b) Log onto the ALTE system.

(c) Enter the identification (if in the database) or otherwise specify the line to be tested. If the line to be tested is in the ALTE database, identification is accomplished by giving the line number or selecting it from a list in the database. If not in the database, the line to be tested must be completely defined so the ALTE is given all specifications and locations necessary for testing to be accomplished.

(d) Select required test resources from the listing of test resources available. The test resources are the terminal servers, modems, or CTS equipment needed to conduct the desired testing within the ALTE system. When successfully logged into the selected test resources, the OPERATION menu will appear. From the OPERATION menu select ACCESS and TEST to obtain access to the line to be tested. If access is successful, the ANALOG ACCESS menu appears.

(e) Split the line and perform looped mode and single-ended tests.

1 Attenuation distortion, three-tone slope, envelope delay, and level and noise testing may be conducted using ALTE sweep tests. Follow instructions on the monitor for the sweep test and when tests of these parameters are completed, store or record the results.

2 Use the multiple tests in single-ended and then looped condition to test the following: 3-tone slope, impulse noise, phase jitter, level and frequency, C-notched noise, and signal-to-noise ratio.

3 If there is a need, other ALTE tests are available on the menus which will allow other tests to be performed to assist in diagnosing the type of difficulty that may be present when a line does not meet specified parameters.

4 When commissioning a line, conduct a test of P/AR in the looped mode and then in each direction. Record the results on Form 6000-14, or use the ALTE printout. P/AR is a weighted measure of total attenuation, phase distortion, and noise. It is most sensitive to envelope delay and return loss problems. P/AR can be used effectively as an indicator of difficulties during preventive maintenance and troubleshooting/fault isolation operations. If the P/AR value in subsequent testing has changed ± 4 units from the value recorded at commissioning, it is likely that some line characteristic has changed significantly and should be further investigated.

5 The testing ends either with the line being considered satisfactory (tested values satisfactorily meet or exceed all key parameters) and placed in service, or with a trouble call to the vendor.

6 Record/store all test results as *benchmark* (for initial acceptance) or *last* (when completing a major test or a total line run).

(2) **Revalidation.** Revalidation of a line that has been out-of-service for maintenance requires retesting of the parameter(s) that required the line be removed from service for maintenance in the first place. Detailed procedures for this testing are the same as that for *Line Acceptance* in subparagraph (1) with the exception that only parameters previously out-of-tolerance must be retested. If these parameter test values are now shown to be within the tolerances of Chapter 3, the line is put back to service and the new test values are filed/stored.

(3) **Acceptance of Composite Lines.** Acceptance of a composite line is accomplished first by testing each segment of the line as detailed in subparagraph (1) to confirm that it meets or exceeds the published standard for its type of service (LINCS VG-6 or VG-8, FTS2000, RCL/LDRCL, et al). Record the segment-by-segment test results on Form 6000-14, or printout the results using the ALTE. This will serve as a baseline for future troubleshooting and fault isolation on the composite line. After testing each segment and confirming they are within tolerances, test the entire composite line as detailed in subparagraph (1) and confirm that it meets or exceeds the standards and tolerances of paragraph 309 for the type of service that the line will be supporting (voice, radio, or data). If responders have been used in conducting line runs or other testing, reset the responders before attempting to place the line in service.

514. ANNUAL LINE RUN USING MANUAL TEST EQUIPMENT.

a. Object. This procedure provides for checking the basic parameters of line performance (gain, attenuation distortion, and signal-to-noise) on an annual basis using manually operated communications test sets.

b. Discussion.

(1) Manual testing of analog lines may be accomplished where the ALTE is not available. This testing will require two individuals and two test sets, one at each end of the line, with communications between the two to coordinate the testing. Testing is accomplished by injecting a known signal into one end of the line and analyzing the signal received at the other end for impairments created by the line. This process is done in both directions, transmit and receive.

(2) The HP4935 Transmission Impairment Measurement System (TIMS), or its equivalent, is commonly found in the field and is capable of performing all required annual line testing. It can also check all chapter 3 parameters for lines used for voice but not data applications. The Hekimian 3700 communications test system (CTS) and CXR Telcom 5200 universal transmission analyzer (UTA) will test all chapter 3 parameters, including those required for data applications. Table 5-1 lists manually operated test equipment found in FAA field facilities. Refer to the table and operators manual to ensure that the unit planned for use is capable of performing the tests required.

(3) Annual line runs are performed on all lines, including standby (or redundant) lines, with the exception of lines described in paragraph 401.

(4) Chapter 3 lists the specific performance parameters, tolerances, and limits applicable to all classes of analog lines used within the FAA.

(5) Annual line runs on composite lines should be performed on an end-to-end basis, with results compared to the composite line parameters listed in paragraph 309. If the results indicate the composite line is not within tolerances, the line should be taken out of service for maintenance. Segment-by-segment tests should then be performed to determine which is defective and corrective action should be taken on the defective segment.

(6) FAA Form 6000-14 may be used to record maintenance action on all analog lines.

c. Test Equipment Required. Two HP4935 TIMS or equivalent communications test sets.

d. Conditions.

(1) Ensure that the line to be tested has been released from service by air traffic control personnel or other user and that the operating equipment at each end has been lifted from the line. Service may be maintained by either providing a satisfactory alternate route for operational data or during scheduled maintenance time when advanced coordination has arranged for the operational service to be unavailable to the user during specified times.

(2) The maximum FAA test tone power level applied at any frequency shall be -13 dBm at the 0 TLP.

NOTE: This power level is used for measuring frequency attenuation, measuring net loss at 1004 Hz, and other line performance evaluations. Equipment lineup levels are specified in applicable equipment orders.

(3) Ensure that the operating equipment at each end has been lifted from the line. To lift equipment, open-line plugs are inserted in the EQUIP jacks on the demarcation jackfield.

(4) The specialist should be familiar with the operation of the test equipment used, and should review the users manual for the test equipment before and during the testing.

e. Detailed Procedure. The following procedure is written around the use of the HP4935 TIMS as it is commonly available when manual testing is required. The steps are easily translated for use with other test sets.

(1) At both ends of the line to be tested, set up a TIMS as follows:

Transmit and receive impedance to 600 Ω
Measurement key on LEVEL FREQUENCY
Display to TRMT
Set transmit frequency to 1004 Hz
Set output level to -13 dBm
Set receive filter to C-message

(1) At both ends of the line to be tested, connect the transmit and receive jacks of the TIMS to the transmit and receive pairs respectively of the line. Connection should be made to the line-side of the jackfield if one is provided at the demarc for the line.

(2) At both ends of the line to be tested, set the display to RCV and read the power level indicated. Record the level on FAA Form 6000-14.

(3) If both TIMS are equipped with the option for measuring P/AR, skip to step (10).

(4) At both ends of the line to be tested, set the display to TRMT, set frequency to 404 Hz, and set output level to -13 dBm.

(5) At both ends of the line to be tested, set the display to RCV and read the power level indicated. Record the level on FAA Form 6000-14.

(6) At both ends of the line to be tested, set the display to TRMT, set frequency to 2804 Hz, and set output level to -13 dBm.

(7) At both ends of the line to be tested, set the display to RCV and read the power level indicated. Record the level on FAA Form 6000-14.

(8) At both ends of the line to be tested, set the display to TRMT, set frequency to 1004 Hz, and set output level to -13 dBm. Press measurement key to select SIGNAL TO NOISE and press filter key to select C-MESSAGE.

(9) At both ends of the line to be tested, set the display to RCV and read the signal-to-C-notched noise ratio in the right display. Record readings on FAA Form 6000-14.

(10) At both ends of the line to be tested, set display to TRMT, set measurement key to P/AR, and set output level to -13 dBm.

(11) At both ends of the line to be tested, set display to RCV and read the value for P/AR. Record the value in FAA Form 6000-14.

(12) Compare readings with published standards and tolerances. If readings are in tolerance, disconnect equipment and return the line to service. If line is not within tolerance, take steps to protect the operational service and contact the service provider for corrective action.

515. "AS REQUIRED" TESTING USING MANUAL TEST EQUIPMENT.

a. Object. This procedure provides for using manually operated communications test sets to perform testing required for initial acceptance of lines, for acceptance of composite lines, and for revalidating lines that were out-of-service for maintenance.

b. Discussion.

(1) Testing of lines is required when the line is initially accepted for service, or after completion of corrective action for a line that was out-of-tolerance. Vendor test data may be used to satisfy this requirement if testing was witnessed by qualified FAA or FAA contract personnel, a copy of test data is provided to the facility, and the line is under real-time monitoring.

(2) Manual testing of analog lines may be accomplished where the ALTE is not available. This testing will require two individuals and two test sets, one at each end of the line, with communications between the two to coordinate the testing. Testing is accomplished by injecting a known signal into one end of the line and analyzing the signal received at the other end for impairments created by the line. This process is done in both directions, transmit and receive.

(3) The HP4935 Transmission Impairment Measurement System (TIMS), or its equivalent, is commonly found in the field and is capable of performing all required annual line testing. It can also check all chapter 3 parameters for lines used for voice but not data applications. The Hekimian 3700 communications test system (CTS) and CXR Telcom 5200 universal transmission analyzer (UTA) will test all chapter 3 parameters, including those required for data applications. Table 5-1 lists manually operated test equipment found in FAA field facilities. Refer to the table and operators manual to ensure that the unit planned for use is capable of performing the tests required.

(4) Chapter 3 lists the specific performance parameters, tolerances, and limits applicable to all classes of analog lines used within the FAA.

(5) The P/AR test should be run end-to-end and with the line looped back to establish a baseline for future testing.

(6) Use FAA Form 6000-14 to record data taken and calculated values for parameters applicable to the line. A separate form is required for each end of a line. Local authorities may also utilize computer printouts (from contractor-automated testing equipment) as the record for such maintenance or may have such printouts attached to a form 6000-14.

c. Test Equipment Required. For lines used in voice applications, two HP4935 TIMS or equivalent are required. For lines used in data applications, two Hekimian CTS or CXR5200 UTA or equivalent are required.

d. Conditions.

(1) Ensure that the line to be tested has been released from service by air traffic control personnel or other user and that the operating equipment at each end has been lifted from the line. Service may be maintained by either providing a satisfactory alternate route for operational data or during scheduled maintenance time when advanced coordination has arranged for the operational service to be unavailable to the user during specified times.

(2) The maximum FAA test tone power level applied at any frequency shall be -13 dBm at the 0 TLP.

NOTE: This power level is used for measuring frequency attenuation, measuring net loss at 1004 Hz, and other line performance evaluations. Equipment lineup levels are specified in applicable equipment orders.

(3) Ensure that the operating equipment at each end has been lifted from the line. To lift equipment, open-line plugs are inserted in the EQUIP jacks on the demarcation jackfield.

(4) The specialist should be familiar with the operation of the test equipment used, and should review the users manual for the test equipment before and during the testing.

e. Detailed Procedure.

(1) Line Acceptance. The following procedure is written in generic terms so that it may be used with different test sets.

(a) 1004-Hz Net Loss and Attenuation Distortion.

1 At both ends of the line to be tested, set up a test set configured as follows: transmit and receive impedance to 600 Ω; transmit frequency to 1004 Hz; output level to -13 dBm; and receive filtering to C-message.

2 At both ends of the line to be tested, connect the transmit and receive sections of the test set to the transmit and receive pairs respectively of the line. Connection should be made to the line-side of the jackfield if one is provided at the demarc for the line.

3 At both ends of the line to be tested, read the received signal power level. Record the level on FAA Form 6000-14.

4 At both ends of the line to be tested, set the transmit frequency to 304 Hz and ensure the output level remains at -13 dBm.

5 At both ends of the line to be tested, read the received signal power level. Record the level on FAA Form 6000-14.

6 Repeat steps 4 and 5 for all frequencies listed on FAA Form 6000-14.

(b) Signal-to-C-Notched Noise. At both ends of the line to be tested, set the transmit frequency to 1004 Hz and the output level to -13 dBm. Select C-message filtering on the receive section of the test set and set measurement mode to signal-to-noise. Read the signal-to-C-notched noise directly on the test sets and record on FAA Form 6000-14. If the test sets used do not directly compute signal-to-C-notched noise, perform the following:

1 Select a C-message filter on the receive section and read the power level of the tone plus noise.

2 Select a C-notch filter on the receive section and read the power level of the noise only.

3 Compute the signal-to-C-notched noise by subtracting the reading of step 2 from that of step 1, and record on FAA Form 6000-14.

(c) Impulse Noise. At both ends of the line to be tested, set transmit frequency to 1004 Hz and level to -13 dBm. Set receive filtering to C-notch (the C-message filter of the TIMS includes a 1010-Hz notch) and measurement mode to impulse noise. Set threshold to that indicated in the *Standards* column of chapter 3 for the line being tested, and duration to 15 minutes. After the 15 minutes is up, record the number of impulses counted by the test sets on FAA Form 6000-14.

(d) Peak to Average Ratio (P/AR).

1 At both ends of the line being tested, set measurement mode to P/AR and set the output level to -13 dBm. Measure P/AR directly on the test sets and record on FAA Form 6000-14.

2 At one end of the line being tested, disconnect the test set and loop back the receive pair to the transmit pair. (Note that the procedure has assumed zero loss lines throughout.) At the other end of the line, measure P/AR directly on the test set and record in the *Comments/Notes* block of FAA Form 6000-14.

(e) Envelope Delay Distortion.

1 At both ends of the line being tested, set up a test set (Hekimian 3700 or CXR 5200 or equal), and set test mode to DELAY or EDD. Designate and set one test set as MASTER and one as SLAVE. The test set designated as MASTER will display results of testing regardless of the direction of the line being tested.

2 Set up the transmit section of each test set for the frequency range applicable for the line being tested. Set frequency step for 100 Hz. Set output level to -13 dBm.

3 Set up test sets for return reference measurements. In this mode, amplitude modulated, swept frequency, vf signals are transmitted from the master to the slave. The slave test set extracts the modulating signal and uses it to modulate a reference 1804-Hz vf signal, which is sent back to the master. This test checks the delay of the line pair transmitting vf from the master end of the line to the slave end. Read test results from the master test set and record on FAA Form 6000-14 for this line pair.

4 Set up test sets for forward reference measurements. In this mode, an amplitude modulated 1804-Hz vf signal is transmitted from the master to the slave. The slave test set extracts the modulating signal and uses it to modulate swept frequency, vf signals, which are sent back to the master. This test checks the delay of the line pair transmitting vf from the slave end of the line to the master end. Read test results from the master test set and record on FAA Form 6000-14 for this line pair.

(f) Intermodulation Distortion.

1 At both ends of the line being tested, set up a test set (Hekimian 3700 or CXR 5200 or equal), and set test mode to IMD. Set output level to -13 dBm.

2 Read the noise-corrected levels for the second and third order intermodulation products and record on FAA Form 6000-14. On the CXR5200, the corrected levels may be read directly on the display. On the Hekimian 3700, procedures contained in the Hekimian users manual must be followed to correct the levels for noise contribution.

(g) Phase Jitter.

1 At both ends of the line being tested, set up a test set (Hekimian 3700 or CXR 5200 or equal), and

select PHS/AMP JTR test. Set test mode to PHASE. Set output level to -13 dBm.

2 Phase jitter is measured over two frequency ranges, standard and standard plus low frequency. The standard range is 20 Hz to 300 Hz, while the standard plus low frequency range is 4 Hz to 300 Hz. Read the phase jitter for both ranges and record on FAA Form 6000-14. On the CXR5200, both readings are present on the display. The Hekimian 3700 uses a soft key to enable/disable the low frequency. On this unit, read the phase jitter with the softkey set to "lf" for the standard (20- to 300-Hz) range and read the phase jitter with the softkey set to "LF" for the 4- to 300-Hz range.

(h) Disposition of Data. Compare readings with published standards and tolerances. If readings are in tolerance, disconnect equipment and place the line to service. Record and store all test results for use as a benchmark in future testing of the line. If line is not within tolerance, contact the service provider for corrective action.

(2) Revalidation. Revalidation of a line that has been out-of-service for maintenance requires retesting of the parameter(s) that required the line be removed from service for maintenance in the first place. Detailed procedures for this testing are the same as that for *Line Acceptance* in subparagraph (1) with the exception that only parameters previously out-of-tolerance must be retested. If these parameter test values are now shown to be within the tolerances of chapter 3, the line is put back to service and the new test values are filed/stored.

(3) Acceptance of Composite Lines. Each segment of a composite line must be tested to confirm that it meets or exceeds the published standard for its type of service (LINCS - VG-6 or VG-8, FTS2000, RCL/LDRCL, or other) as the line is being activated. Record both the segment-by-segment and the end-to-end testing results as baseline information that will assist when later having to troubleshoot or fault isolate on a composite line. A separate FAA Form 6000-14 is required for each end and each segment of a composite line. The end-to-end tolerance levels for a composite line must then be tested to ensure it meets the tolerances listed in paragraph 309 of chapter 3 that are established for the type of service that the line will be supporting (voice, radio, or data). These tolerances are based on the type of service to be carried by the line rather than the capabilities of the line segments used to make up the composite line.

516. MULTIPOINT LINE PERFORMANCE CHECKS.

a. Discussion. Multipoint lines are generally provided by leased services vendors who bridge together a number of point-to-point lines to allow intercommunication between three or more end points. (See appendix 3 for a more detailed discussion of multipoint lines.) FAA maintenance responsibilities and capabilities for multipoint lines are limited since bridging devices used are primarily under vendor control and the vendor provides full-period monitoring for these leased lines.

b. Acceptance and Revalidation. In general, the FAA will accept a multipoint line from the vendor by having user personnel verify that all end points can successfully communicate with appropriate other end points and FAA technical personnel verify, from vendor supplied test reports, that all lines meet or exceed specified parameters when tested by the vendor prior to being placed into full period monitoring. Revalidation of a line after failure will be based on performing the following functional checks.

(1) Voice multipoints. Functional checks for voice multipoint lines will verify that all end points can both communicate with and signal to all other end points.

(2) Data multipoints. Data multipoint lines functional checks will verify that the controlling end and each remote end point can successfully exchange data.

517.-530. RESERVED.

SECTION 2. SPECIAL MAINTENANCE PROCEDURES.

531. COMPOSITE LINE TROUBLESHOOTING. Isolation of trouble in a composite line must be done by testing each segment sequentially (starting with the nearest segment and then adding on each successively more distant segment) until the trouble can be identified and localized to a single segment; then appropriate maintenance action can be directed and accomplished. To facilitate remote testing, fault isolation, and trouble shooting, it is helpful to have responders or other remotely controlled test devices at each interface point where different types of line segments come together within a composite line. If end-to-end testing results are unsatisfactory, adjust parameters on FAA owned systems. If adjusting parameters on FAA owned segments does not provide satisfactory results, refer the line back to the circuit designer.

532. COMPRESSION WITHIN THE NETWORK. Although a compression test is not called for during normal routine maintenance, or even during most out-of-service conditions, it is very important to recognize and correct the problem when it does occur. When all normal tests, levels, frequency response, and noise have been made, associated standards met, and yet the service still will not work; additional tests must be performed.

NOTE: Telcos may also use terms like *tracking* and *gain linearity* when addressing what is discussed here as compression.

a. A communications line becomes nonlinear when a level change at the input is not reflected as an identical level change at the output. In most cases, compression is apparent when the level changes at the input result in little or no changes at the output. In fact, it may appear as if agc is present on the line.

b. Compression may be caused by defective amplifiers, improper equipment and circuit alignment, or the wrong value of attenuators at intermediate points along the path of the line.

c. Symptoms of compression problems are more prevalent on services that combine voice and control tones such as air/ground or monitor and alarm control lines. The application of voice may cause bit errors in the frequency-shift keyed (FSK) portion or false alarms on the monitoring equipment.

d. Gain linearity or tracking represents the ability of the carrier system to cause a corresponding change at the output that tracks with the input change.

e. The recommended testing procedure is to insert 1004 Hz at 0 dBm at the input and reduce the level in 5-dB increments to -35 dBm. The receive end should track within ±1 dBm on an end-to-end (not looped) basis. If testing needs to be extended beyond -35 dBm, levels between -35 and -50 dBm should track within ±1.5 dBm. No peak should go above 0.0 dBm and average no higher level than -13 dBm for more than 3 seconds.

533.-599. RESERVED.

CHAPTER 6. FLIGHT INSPECTION

600. GENERAL. Since analog lines are an integral component of various certifiable systems, an independent flight check is not required. Refer to the latest version of OAP 8200.1, United States Standard Flight Inspection Manual.

601.-699. RESERVED.

CHAPTER 7. MISCELLANEOUS

700. MULTIPOINT LINES.

a. General. Multipoint lines are used for voice or data communications where a controlling end point needs to communicate with more than one other end point. In the FAA, most voice multipoint lines are used for interphone service between controllers or from controllers to selected sites throughout an airspace, generally with all end points able to communicate with all other end points. Data multipoints are used in applications where the remote end points sequentially exchange data with the controlling point but not with other remote end points. On LINCS the bridging is generally accomplished either at the LINCS node or at a local exchange carrier (LEC) central office.

b. Maintenance Philosophy.

(1) Leased Multipoint Lines. Since the bridges for leased multipoint lines are almost universally located within vendor spaces or central offices and are provided full-period monitoring, FAA personnel will not be required to perform separate line runs before accepting leased multipoints. (See chapter 4.) When the vendor turns over the multipoint line, FAA user personnel will perform functional checks to ensure that the entire line is providing required communications between end points as required and technical personnel will review vendor provided reports of line acceptance testing to ensure that the line was within appropriate parameters.

(a) Functional Checks. User personnel will conduct checks from the controlling location of the multipoint line to all remote ends to determine that required voice or data communications are satisfactory and that signaling, if required, is working. The operational line must support the stated requirements for communications either among all end points or between the controlling end point and sequentially with each remote end point.

(b) Review of Vendor Test Reports. FAA technical personnel will review vendor supplied test reports to ensure that all line segments of the multipoints were within acceptable parameters when accepted and placed into full-period monitoring.

(c) Corrective Action. After acceptance, when the user reports unsatisfactory operation of a multipoint line, FAA personnel will test to determine if the paths from FAA demarcs to end user equipment at each end are working properly. When FAA portions of the multipoint are determined to be operating correctly, but the line is still not working satisfactorily, then the entire multipoint line will be turned over to the vendor for corrective action.

(2) FAA-Owned Bridges/Multipoint Lines. Maintenance will be as specified in regional supplements for the region that designed and installed the multipoint lines.

c. LINCS Multipoint Lines. LINCS multipoint lines will be designed by the vendor in accordance with contract specifications and FAA requirements.

(1) The 3250-Hz tone used for monitoring VG-6 lines by the LINCS network management center is removed from multipoints before being connected to the bridge so that no monitoring tones cross the bridge.

(2) Carrier detection is used for monitoring LINCS VG-8 lines and does not need any special handling for use on multipoint data lines.

d. VOICE MULTIPOINT LINES. The majority of voice multipoints are provided under the LINCS contract. The LINCS vendor will design the voice multipoint line to meet FAA requirements, generally using VG-6 point-to-point lines from the site of the multipoint bridge to selected end points.

e. DATA MULTIPOINT LINES. Data multipoints will be designed using LINCS VG-6 or VG-8 lines to connect remote end points to the bridge. Remote end points are able to exchange data with the controlling end point but not with other remote end points.

701. ALTE ACCEPTANCE MASKS.

a. General. The Hekimian REACT 2000/Automated Line Test Equipment (ALTE) used at FAA ARTCCs, and selected other facilities, has the capability of developing and using a series of computer macro programs that are called acceptance masks. These acceptance masks can provide the ALTE operator with information on a line being tested as to whether that line passed or failed a set of identified parameters. This paragraph establishes the values in the masks for circuits in chapter 3 of this order and identifies how these masks may be used in FAA maintenance of analog lines.

b. Guidelines. The parameters listed on the blue pages which are chapter 3 of this order (as modified by all official changes) will take precedence in determining acceptable parameter values. Acceptance masks must be checked and modified as necessary to keep them in compliance with parameters listed in chapter 3.

(1) Masks may be developed locally to expedite maintenance operations. Specific guidance on how to enter parameter values from chapter 3 are shown below.

(2) Local authorities must ensure that both acceptance and failure of analog lines remain in strict compliance with chapter 3 parameters. It is suggested that the local ALTE transportation system specialist confirm periodically (semi-annually) that local ALTE acceptance masks used are in compliance with the parameter tolerances in this order.

(3) When there is conflict between an ALTE acceptance mask and chapter 3 of this order, chapter 3 governs.

(4) The telecommunications industry terms used in the Hekimian documentation are defined as follows.

(a) Acceptance limit (AL) is the maximum margin value or deviation that is allowed at service turn-up or acceptance. For establishing ALTE acceptance masks, when the document requires the AL limit, use the *standard* value from chapter 3.

(b) Immediate action limit (IAL) is the boundary of acceptable performance and the threshold beyond which the local exchange carrier will accept a customer's trouble report and take immediate corrective action. When the IAL limit is identified, use the tolerance value from the *initial* column of chapter 3.

c. Detailed Entries.

(1) The specific details for acceptance masks are included in part 9 of the current Hekimian documentation on ALTE/REACT 2000 (HKMN 660-750-025) under the section on REACT SMARTEST in the segment that covers the DS0 Acceptance Database. Since the documentation is revised with each new software release, ensure that documentation and software release are in synchronization. The following subparagraphs give guidance in developing acceptance masks for analog lines used in the FAA.

(a) MASK. Name of the type of circuit as used in chapter 3.

(b) 1004-Hz Loss. Enter the positive and negative deviations in dB as shown in the blue pages.

(c) Attenuation Distortion in dB. Enter the frequency ranges and standards/tolerances from the blue pages. Enter the same value in both the AL and IAL columns. (AL is a required entry.)

(d) Impulse Noise. Enter 15 minute time period. Enter a four digit number, 0015, in the IAL LO entry for the number of incursions allowed in the 15 minute time period.

(e) Delay in μsec (Envelope Delay Distortion). Enter the values for AL/Standard and IAL/Initial from the blue pages and use a leading zero if necessary to make the entry a four-digit number.

(f) Jitter. Enter the degrees of initial tolerance as identified in the blue pages (as stated in the Hekimian document, BELL indicates standard weighting of 20 Hz-to-300 Hz and LF indicates the extended low frequency weighting of 4 Hz-to-300 Hz.)

(g) IMD R2, R3 (Intermodulation Distortion). Enter initial tolerance values under the IAL column. The left two-digit number corresponds to the level of second order IMD products and the right number corresponds to the level of third order IMD products.

(h) P/AR. Leave blank. There is no standard value of P/AR that is applicable for all lines, even those of a common type (VG-6, VG-8, etc.). An acceptable P/AR value will very from line-to-line.

(i) Signal-to-C-Notch Noise and Impulse Noise. There are four fields available in both the AL and IAL columns. In the second field (between the first and second commas) enter the initial tolerance value for signal-to-C-notched noise IAL. In the fourth field (just to right of the third comma) enter the initial tolerance value for impulse noise in dBRNC0. Enter the same values in all mileage bands.

(2) The examples shown in figures B-1, B-2 and B-3 show the mask entries for the basic version of the mask for LINCS VG-6, LINCS VG-8, and FTS2000 lines at the time this Order 6000.22 was published and may need to be revised locally as this order is changed.

FIGURE 7-1. ALTE MASK FOR LINCS VG-6 LINES

```
MASK: VG-6                                  AL                          IAL
Frequency shift (Hz)                         ,                           ,
        1004 Loss (dBm)                      ,                     -01.5, +01.5
3 tone slope 404 & 2804 (dBm)                ,                     -01.0, +04.0
Attenuation  0504-2504 (Hz)            -01.0, +03.0                -01.0, +03.0
distortion   0404-2804 (Hz)            -01.0, +04.0                -01.0, +04.0
in dB        0304-3004 (Hz)            -01.0, +05.0                -01.0, +05.0
                 -     (Hz)                  ,                           ,
Impulse nse  (15 mins)     HI:     MID:     LO:     HI:15     MID:15      LO: 15
Hits & dropouts            GH:     PH:      DO:     GH:       PH:         DO:
Delay in µS      AL            IAL                        AL                IAL
804-2604         0700          0700              -
 -                                               -
 -                                               -
Jitter           BELL:   LF:   BELL: 05  LF: 10 IMD R2, R3    ,            33, 40
P/AR                                          Echo control
      C-msg,      C-notch,     Signal to Noise,  impulse noise threshold per miles
<= 50          , , ,            , 30,   , 67    <= 2500     , , ,          , 30,   , 67
<= 100         , , ,            , 30,   , 67    <= 4000     , , ,          , 30,   , 67
<= 200         , , ,            , 30,   , 67    <= 8000     , , ,          , 30,   , 67
<= 400         , , ,            , 30,   , 67    <= 20000    , , ,          , 30,   , 67
<= 1000        , , ,            , 30,   , 67    Satellite   , , ,          , 30,   , 67

  F1-AHEAD, F2-BACK, F3-FIRST, F4-HELP, F5-TOP, F6-BOTTOM, F7-DELETE, F8-EXIT
```

FIGURE 7-2. ALTE MASK FOR LINCS VG-8 LINES

```
MASK:  VG-8                                  AL                        IAL
Frequency shift (Hz)                          ,                         ,
          1004 Loss (dBm)                     ,                  -01.5, +01.5
3 tone slope 404 & 2804 (dBm)                 ,                  -01.0, +02.0
Attenuation  0404-2804  (Hz)           -01.0, +02.0              -01.0, +02.0
distortion     0304-3004  (Hz)         -01.0, +05.0              -01.0, +05.0
in dB              -        (Hz)              ,                         ,
                   -        (Hz)              ,                         ,
Impulse nse   (15 mins)     HI:      MID:       LO:      HI:15      MID:15      LO:  15
Hits & dropouts             GH:      PH:        DO:      GH:        PH:         DO:
Delay in µS       AL             IAL                          AL                 IAL
804-2604        0700            0700          -
   -                                          -
   -                                          -
Jitter        BELL:    LF:    BELL: 04   LF: 09   IMD R2, R3    ,               45, 48
P/AR                                              Echo control
      C-msg,     C-notch,     Signal to Noise,     impulse noise threshold per miles
<=  50          ,  ,  ,          , 32,   , 67      <=  2500    ,  ,  ,          , 32,   , 67
<=  100         ,  ,  ,          , 32,   , 67      <=  4000    ,  ,  ,          , 32,   , 67
<=  200         ,  ,  ,          , 32,   , 67      <=  8000    ,  ,  ,          , 32,   , 67
<=  400         ,  ,  ,          , 32,   , 67      <=  20000   ,  ,  ,          , 32,   , 67
<=  1000        ,  ,  ,          , 32,   , 67      Satellite   ,  ,  ,          , 32,   , 67


F1-AHEAD,  F2-BACK,  F3-FIRST,  F4-HELP,  F5-TOP,  F6-BOTTOM,  F7-DELETE,  F8-EXIT
```

FIGURE 7-3. ALTE MASK FOR FTS2000 LINES

MASK: FTS2000 AL IAL
Frequency shift (Hz) , ,
1004 Loss (dBm) , -02.0, +02.5
3 tone slope 404 & 2804 (dBm) , -02.0, +06.0
Attenuation 0404-2804 (Hz) -02.0, +06.0 -02.0, +06.0
distortion 0304-3004 (Hz) -03.0, +12.0 -03.0, +12.0
in dB - (Hz) , ,
- (Hz) , ,
Impulse nse (15 mins) HI: MID: LO: HI:15 MID:15 LO: 15
Hits & dropouts GH: PH: DO: GH: PH: DO:
Delay in μS AL - IAL AL IAL
804-2604 1250 1250 -
- -
- -
Jitter BELL: LF: BELL: 08 LF: 12 IMD R2, R3 , 45, 43
P/AR Echo control
C-msg, C-notch, Signal to Noise, impulse noise threshold per miles
<= 50 , , , , 28, , 71 <= 2500 , , , , 28, , 71
<= 100 , , , , 28, , 71 <= 4000 , , , , 28, , 71
<= 200 , , , , 28, , 71 <= 8000 , , , , 28, , 71
<= 400 , , , , 28, , 71 <= 20000 , , , , 28, , 71
<= 1000 , , , , 28, , 71 Satellite , , , , 28, , 71

F1-AHEAD, F2-BACK, F3-FIRST, F4-HELP, F5-TOP, F6-BOTTOM, F7-DELETE, F8-EXIT

702.-799. RESERVED.

APPENDIX 1: GLOSSARY OF TELECOMMUNICATIONS TERMS

A and B Signaling. The procedure most often used in T1 transmission facilities in which one bit, robbed from each of the 24 subchannels in every sixth frame, is used for carrying dial and control information.

Acceptance Limit (AL). A telecommunications industry term for the maximum value of, or deviation from, a design parameter that is allowed at service turnup or acceptance.

Acoustic Coupler. A device that converts electrical signals into audio signals, enabling data to be transmitted over telephone lines via a conventional telephone handset.

Address. A unique sequence of letters or numbers for the location of data or the identity of an intelligent device.

ADPCM (Adaptive Differential Pulse Code Modulation). A technique that allows analog signals to be carried on a 32 kb/s digital channel. Sampling is performed at 8 Hz with 3 or 4 bits used to describe the difference between adjacent samples.

Adaptive Routing. A means of selecting the optimum path for message transfer or packet routing.

Algorithm. A set of instructions or mathematical formulas used to solve a given communications problem.

Alternate Route. A redundant or diversity transmission route that provides the same telecommunications connectivity as the primary route to which it is referenced.

Analog. An electrical signal that varies continuously in amplitude or frequency depending on changes in sound, light, heat, etc.

Analog/Digital Converter (A/D). A device that converts an analog transmission signal into digital format.

ANSI. American National Standards Institute; the principle standards development body supported by over 1000 American trade organizations, professional societies and companies. The U. S. member body to ISO (International Standards Organization).

ASCII: American Standard Code for Information Interchange; a seven-bit-plus parity code established by ANSI to establish a uniform means of transferring information between data processing systems, communications systems, and terminal equipment.

Attenuation Distortion. The difference in loss at one frequency with respect to the loss at a reference frequency; the reference frequency is 1004 Hz unless otherwise specified. Attenuation distortion is controlled either at specified frequencies, or throughout a frequency band. (See also *Slope*.)

Automatic. A capability that results in an action being initiated within the network without human intervention.

AWG. American Wire Gauge; conventional designator of wire size.

Backbone Network. The high-density portion of a network that connects primary nodes.

Bandpass. The portion of a band, expressed in frequency differences (bandwidth), in which the signal lost (attenuation) of any frequency when compared to the strength of a reference frequency is less than the value specified in the measurement.

Bandwidth. The range of frequencies available for telecommunications; the difference expressed in Hertz between the highest and lowest frequencies of a band. The theoretical maximum speed at which a given network topology, line or communication line operates.

Baud. Unit of signaling speed. The speed in baud is the number of discrete conditions or events per second. (Baud is an older term that was used mostly for teletypes, the newer term is bits per second).

Bellcore. Bell Communications Research; organized and funded by the Bell Operating companies following AT&T divestiture, for the purpose of establishing telephone-network standards and interfaces; includes much of what had been Bell Laboratories.

Bell Operating Company (BOC). Any of the 22 operating companies created by the AT&T divestiture.

Blocking. The inability of a telecommunications system to establish a connection because paths are unavailable.

Bus. A simultaneous and non-interfering transmission path servicing multiple devices.

C Conditioning. Type of line conditioning that controls attenuation, distortion, and delay distortion so they lie within specific limits.

C-Message Noise. The frequency-weighted, short-term average noise within an idle line. The frequency weighing, called C-message, is used to account for the variations in 500-type telephone set transducer efficiency and user annoyance to tones as a function of frequency.

C-Notched Noise. The C-message, frequency-weighted noise on a line with a holding tone, which is removed at the measuring end through a notch (very narrow band) filter.

Call. The sequence of events begun when an end user makes a request for service and provides an address code, and concluded when communication between the end users has terminated.

Central Office (CO). The telephone company switching facility or center at which subscribers' local loops terminate. It handles a specific geographic area and is identified by the first three digits of the local telephone number. Since divestiture, these are invariably the facilities of the local Bell operating company.

Channel Bank. A device that multiplexes many slow-speed voice or data conversations onto a high-speed link and controls the flow of these conversations.

Circuit. A physical or logical path allowing the transmission of information; the path connecting a data source and a data "sink" (receiver). The term "circuit" may be used interchangeably with "channel," "line," or "path."

Circuit Diversity. A physical and electrical separation in routing of transmission paths such that a failure at one geographical location will not cause loss of both paths.

Comite Consultatif International de Telephonie et de Telegraphie (CCITT). International Consultative Committee for Telephone and Telegraph, a United Nations organization.

Composite Line. An end-to-end analog line made up of two or more line segments provided by different suppliers.

Control Station. The station on a network that supervises control procedures, including polling, calling, and error recovery.

Copper Facility. Any wire-based transmission medium utilizing copper wire or cable.

Crosstalk. The unwanted transfer of energy from one line (the disturbing line) to another line (the disturbed line).

Customer-Premise Equipment (CPE). Equipment and facilities on the customer/FAA side of the point of interconnection with the telecommunications network.

D Conditioning. A type of conditioning that controls harmonic distortion and signal-to-noise ratio so that they reside within specified limits.

Data. Digitally represented information, which includes voice, text, facsimile, and video.

Database. Collection of data which is structured and organized in a disciplined fashion to facilitate information retrieval.

DB (DECIBEL). The logarithmic unit of signal power ratio commonly used in telephony. It is used to express the relationship between two signal powers, usually between two acoustic, electric, or optical signals; it is equal to 10 times the common logarithm of the ratio of the 2 signal powers.

DBM. Decibel referenced to one milliwatt; relative strength of a signal, calculated in decibels, when the signal is compared in a ratio to a value of one milliwatt; used mainly in telephony to refer to relative strength of a signal (e.g., at 0 dBm, a signal delivers 1 milliwatt to a line load, while at -30 dBm a signal delivers .001 milliwatt to a load).

DBRN. A unit used to express noise power relative to one picowatt (-90 dBm).

DBRNC. Noise power in dBRN, measured with C-message weighing.

DBRNC0. Noise power in dBRNC referred to or measured at a zero transmission level point (0/TLP).

Decibel (dB). See dB above.

Delay Distortion. Change in signal from transmitting end to receiving end resulting from the non-uniform speed of transmission of various frequency components of a signal through a transmission medium.

Delay Time, End-To-End. The time to traverse the leased system from one end user location to another, including processing, queuing, connecting, transmission/retransmission and propagation delays. Measure of round trip transmission delay. Useful for detecting possible cause of protocol timeouts.

Demarcation (DEMARC) Point. The demarcation point between the wiring that comes in from the local telephone company, and customer-premises equipment or CPE.

Demodulation. The process of retrieving a signal from a modulated carrier wave.

Deviation. The departure from a standard or specified value.

D/I. See Drop and Insert below.

DIP Site. A drop and insert point, usually on the RCL, at which voice grade lines are dropped and inserted.

Digital. Referring to communications procedures, techniques, and equipment by which information is encoded as either a binary *1* or *0*; the representation of information is discrete binary form, discontinuous in time, as opposed to the analog representation of information in variable, but continuous, waveforms.

Digroup. A digital group, or when 24 voiceband analog channels are combined or multiplexed to form a DS-1 signal.

Drop and Insert. A term applied to a multiplexer that can add data (insert) to a T1 data stream, or act as a terminating node (drop) to other multiplexers connected to it.

Drop Cable. In local area networks, a cable that connects perpendicularly to the main network cable, or bus, and attaches to data terminal equipment (DTE).

Echo. Part of a signal transmission reflected or otherwise returned with sufficient magnitude and delay to be received as interference.

Echo Return Loss (ERL). A frequency-weighted measure of return loss over the middle of the voiceband (approximately 560 to 1965 Hz), where talker echo is most annoying.

EIA (Electronics Industry Association). A U.S. standards organization specializing in the electrical and functional characteristics of interface equipment.

End-User. An end-user may be either an FAA or contractor person who will operate equipment that uses the telecommunications medium.

End-User Location (EUL). A place at which a leased transmission line is terminated. Service is delivered to a specific demarcation point at the location. Each EUL will be designated by the government as a type A location (EUL-A) or a type B location (EUL-B). See type A or type B locations.

Envelope Delay Distortion (EDD). A characteristic of analog lines that results when some frequencies arrive ahead of others, even though they were transmitted at the same time. It is normally expressed as a difference in time between arrival of the frequencies at the receive end of a line; difference in times between the frequency that arrived last and the frequency that arrived first.

Exchange. A unit established by a telephone company for the administration of communications service in a specified geographic area that usually embraces a city, town, or village and its environs.

Expected Measured Loss (EML). The calculated value of the 1004-Hz loss that one would expect to measure between two test points with the proper terminating impedances at the test points. It is the sum of the inserted connection loss and test access loss including any test pads.

FAA Designated Demarcation Point. This DEMARC is the physical point interconnecting the government communications equipment and the leased system.

Facilities. Any telephone company cable, poles, conduit, microwave, or carrier equipment, wire center distributing frames, central office, switching equipment, computers (both hardware and software), business machines, etc., utilized to provide services offered.

FCC: Federal Communications Commission, regulates U.S. communications.

Filter. Device that transmits a certain range of frequencies while suppressing unwanted frequencies or noise, or while separating lines in communications lines.

Frequency Shift. The difference between the frequency of a signal applied at the input of a line and the frequency of that signal at the output of the line.

Full Duplex. The capability of transmission in either direction, at the same time.

Gain/Frequency Characteristic. The gain-versus-frequency characteristic of the line over the bandwidth provided.

Government Facility. A government facility is a location owned, operated, leased, or contracted by or for the government.

Half Duplex. Transmission in either direction, but not at the same time.

Harmonic. An alternating signal whose frequency is an integral multiple of the fundamental basic frequency.

Hertz (Hz). Measurement that distinguishes electromagnetic waveform energy, number of cycles, or complete waves that pass a reference point per second; measurement of frequency, by which one Hertz equals one cycle per second.

Hybrid. An electronic line or transformer that interconnects a local (two-wire) loop with four-wire long-haul facilities.

Immediate Action Limit (IAL). A telecommunications industry term for the bound of acceptable performance and the threshold beyond which the local exchange carrier will accept a customer's trouble report and take immediate corrective action.

Impulse Noise. Any momentary occurrence of the noise on a line significantly exceeding the normal noise peaks. It is analyzed by counting the number of occurrences that exceed a threshold during a specified period of time.

In-Band Signaling. Use of audio tones inside the conventional voice frequency line to convey signaling information.

Interface. The point at which two systems, or two parts of one system, interconnect.

Interference. Any unwanted noise or crosstalk on a communications line that reduces the intelligibility of the desired speech or signal.

Intermodulation Distortion (IMD). A measure of the nonlinearity of a line. It is measured using four tones and evaluating the ratios (in decibels) of the transmitted composite four-tone signal power to the second-order products of the tones (R2), and the third-order products of the tones (R3).

Interexchange Carrier (IXC). Any corporation engaged for hire in interstate or foreign communication by wire, fiber, or radio between two or more local access and transport areas (LATA's). This does not preclude carrying intra-LATA traffic concurrent with state regulatory approval.

Jitter. The slight movement of a transmission signal in time or phase that can introduce errors and loss of synchronization in high-speed synchronous communications; see Phase Jitter.

K/bits or kb/s. Kilobits per second; standard measure of data rate and transmission capacity.

Kilohertz (kHz). One thousand Hertz or one thousand cycles per second.

LED (Light Emitting Diode). A semiconductor light source that emits visible light or invisible infrared radiation.

Line Conditioning. Telephone company service that reduces envelope delay, noise, and attenuation distortion, enabling the subscriber to transmit higher speed data than over traditional telephone lines.

Local Access. The connection between an EUL-B and a node.

Loss Deviation. The departure of the actual loss from the designated value.

Local Access and Transport Area (LATA). One of 161 local telephone serving areas in the United States, generally encompassing the largest standard statistical metropolitan areas; subdivisions established as a result of the Bell divestiture that now distinguish local from long distance service; lines with both end-points within the LATA (intra-LATA) are generally the sole responsibility of the local telephone company, while lines that cross outside the LATA (inter-LATA) are passed on to an inter-exchange carrier.

Local Area Network (LAN). A data communications system confined to a limited geographical area with moderate to high data rates (100 kb/s to 50 Mb/s). The area may consist of a single building, a cluster of buildings or a campus-type arrangement. The network uses some type of switching technology, and does not use common carrier lines - although it may have gateways or bridges to other public and private networks.

Local Exchange Carrier (LEC). An organization that provides intra-LATA telecommunications services to the public.

Loopback. Diagnostic procedure used for transmission devices; a test message is sent to a device being tested, which is then sent back to the originator and compared with the original transmission; loopback testing may be within a locally attached device or conducted remotely over a communications line.

Main Distribution Frame. In telephony, a structure where telephone-subscriber lines are terminated; in conjunction with a PBX, the place where central office telephone lines are connected to on-premises extensions; at a telephone central office, a site where subscriber lines terminate.

Modem. Modulator/demodulator; electronic device that enables digital data to be sent over analog transmission facilities.

Modulation. Modifying some characteristics of a wave form.

Monitor. (1) A video display. (2) Any hardware or software that supervises the operation of a system and indicates any deviation from its standard operating procedure.

MTBF. Mean Time Between Failures. Average for one device.

MTTR. Mean Time To Repair.

Multidrop Line. A communications line that interconnects several stations in different geographical locations. See Multipoint Line.

Multiplex. A technique to use a single transmission line to provide several transmission lines, such as by sharing the time of the line (time-division multiplexing) or superimposing many frequencies at the same time (frequency-division multiplexing) so that many signal sources and receivers may communicate during a given time period.

Multiplexing/Multiplexer. The combining of multiple data lines onto a single transmission medium; any process through which a line normally dedicated to a single user can be shared by multiple users; typically user data streams are interleaved on a bit or byte basis (time division) or separated by different carrier frequencies (frequency division).

Multipoint Line. A line providing simultaneous transmission among three or more separate points. also a multidrop line.

Network Control Signaling. The transmission of signals in the telecommunications system that perform functions such as supervision (control, status, and charge signals), address signaling (e.g., dialing), calling and called number identifications, rate of flow, service selection, error control, and audible tone signals (call-progress signals indicating reorder or busy conditions, and alerting) to control the operation of the telecommunications system.

Network Termination Equipment (NTE). Network component that links directly to the terminating equipment.

Node. A point in the network which is interconnected to at least two other nodes via digital facilities (paths) which are physically diverse. A node may be located at a vendor location or at an FAA location.

Noise. Random electrical signals, introduced by line components or natural disturbances that tend to degrade the performance of a communications line.

Non-Blocking. A capability of the network such that the total number of available transmission paths is equal to the number of ports. Therefore, all ports can have simultaneous access through the network.

Nyquist Theorem. In communications theory, a formula stating that two samples per cycle is sufficient to characterize a bandlimited analog signal, in other words, the sampling rate must be twice the highest frequency component of the signal (e.g., sampling at 8 kHz for a 4-kHz analog signal).

Off-Hook. The supervisory state indicative of the active (in use) condition.

On-Hook. The supervisory state indicative of the idle condition.

Out-of-Band Signaling. Use of narrowband filters to place the voice signal on a carrier line below 3400 Hz, reserving the 3400-to-3700-Hz band for supervisory signals.

PAM. Pulse amplitude modulation.

Path. An analog or digital route between two nodes.

PCM (Pulse Code Modulation). Digital transmission technique that involves sampling of an analog information signal at regular time intervals and coding the measured amplitude value into a series of binary values, which are transmitted by modulation of a pulsed or intermittent carrier; a common method of speech digitizing using 8 bit code works or samples and a sampling rate of (typically) 8 Khz.

Peak to Average Ratio (P/AR). A test to determine a line's overall bandwidth and phase nonlinearity and thus its ability to effectively transmit high speed data traffic.

Phase Jitter. The measurement, in degrees out of phase, that an analog signal deviates from the referenced phases of the main data-carrying signal; often caused by alternating-current components in a telecommunications network.

Point of Presence (POP). A physical location within a LATA established by an IXC for the purpose of obtaining LATA access and LEC-provided access services. POP applies to both switched and dedicated access, although different POPs may be used for different services.

Point-to-Point. Describing a line that interconnects two points directly, where there are generally no intermediate processing nodes, computers, or branched lines, although there could be switching facilities; a type of connection, such as phone-channel line, that links two, and only two, logical entities. See Multipoint Line.

Polling. A means of determining if devices on a multipoint line are alive and responding.

POTS. Plain old telephone service.

Power Level. The ratio of the power at a given point to an arbitrary amount of power chosen as a reference. Usually expressed in decibels based on 1 milliwatt (dBm) or 1 watt (dBw).

Preventive Maintenance. Maintenance, such as periodic inspection, cleaning, and adjustment intended to prevent system malfunction.

RAM (Random Access Memory). Semiconductor read-write volatile memory. Data stored is lost if power is turned off.

Ringdown. Signaling used in manual systems where picking up one phone automatically rings another or signals an operator.

Signal-to-Noise Ratio (SNR). The ratio of the signal power to noise at a given point in a given system (usually expressed in decibels).

Site Level Verification. Level of verification usually performed at the designated site that will verify overall system requirements.

Slope Also Three-Tone Slope or Gain Slope). The loss at 404 and 2804 Hz relative to that at 1004 Hz.

Stability. The property of maintaining a constant value during a specified time interval. Variations from the initial value may be called drift if the change is relatively slow, and jitter or noise if the change is relatively fast.

Status Reporting. The process by which the routing of status information concerning leased system failures and repairs are broadcast to all devices that may need the information for message routing and system monitoring and control.

Subsystem. A grouping of one or more equipment items that perform a function that is a part of an overall system product.

Subsystem-Level Verification. Level of verification usually accomplished at the contractor's facility that will verify subsystem requirements under ambient conditions.

System. An operational grouping of subsystems that compose the leased system. This grouping may include emulators and test fixtures to simulate the operational configuration of the leased system equipment.

System Level Verification. This level of verification is usually accomplished at the contractor's facility and will verify that the network configuration and design will meet the system requirements under controlled electrical, mechanical, and environmental conditions.

T1. AT&T term for a digital carrier facility used to transmit a DS-1 formatted digital signal at 1.544 Mb/s.

T Carrier. A time-division-multiplexed (typically telephone company supplied) digital transmission facility, usually operating at an aggregate data rate of 1.544 Mb/s and above.

Tariff. The formal process whereby services and rates are established by and for communications common carrier; submitted by carriers for government regulatory approval, reviewed, often amended, and then (usually) approved; the published rate for a specific communications service, equipment or facility that constitutes a contract between the user and the communications supplier or carrier.

TELCO. Telephone central office, in most usages, but also a generic abbreviation for telephone company.

Test. A method of verification wherein performance is measured during or after the controlled application of functional and/or environmental stimuli. Quantitative measurements are analyzed to determine the degree of compliance. The process uses laboratory equipment, procedures, and/or services.

Transient. An abrupt change in voltage, of short duration.

Transmission Level Point (TLP). A point in a transmission system at which the ratio, usually expressed in decibels, of the power of a test signal at that point to the power of the test signal at a reference point, is specified. For example, a zero transmission level point (0 TLP) is an arbitrarily established point on a communication line to which all relative levels at other points in the line are referred.

Trunk. A dedicated aggregate telephone line connecting two switching centers, central office, or data concentration devices.

Turn Up. Operational verification of a transmission line after cutover.

Two-Wire to Four-Wire Conversion. An arrangement that converts a four-wire transmission path to a two-wire transmission path to allow a four-wire facility to connect to a two-wire entity such as a trunk line or switching system.

Type A Locations. Type-A locations (designated EUL-A) are major, critical facilities requiring diverse telco entrance facilities, high reliability, and high availability. See also End-Use Locations.

Type B Locations. Type-B locations (designated EUL-B) are less critical facilities that do not have the stringent requirements for diversity, reliability, or availability like those for EUL-A locations. A location that is not designated by the government as an EUL-A, is an EUL-B.

Voice-Bandwidth Line. A line with frequency response characteristics to effectively transmit voice-frequency signals. (A frequency range of about 300 to 3000 Hz.)

Voice Frequency (vf). Describing an analog signal within the range of transmitted speech, typically from 300 to 3400 Hz; any transmission supported by an analog telecommunications line.

Voice Grade (VG). A term used to describe the performance characteristics of a channel, line, facility, or service that is suitable for the transmission of speech, digital or analog data, or facsimile, generally with a frequency range of about 300 to 3000 Hz.

Zero, Zero Transmission Level Point (0,0 TLP). Indicates that there are two reference points on a line between which there will be no overall change in signal power. Establishes unity gain (no loss or gain) between these points of reference.

Memorandum

U.S. Department of Transportation

Federal Aviation Administration

Subject: <u>INFORMATION</u>: Suggested Improvements to Order 6000.22A, Maintenance of Analog Lines

Date:

From:

Signature and Title

Reply to Attn. of:

Facility Identifier
AF Address

To: Manager, National Airway Systems Engineering Division, AOS-200

Problems with present handbook.

Recommended improvements.